CR 54484

[redacted]

RECEIVED APR 11 1968

[redacted]

GENERAL DYNAMICS

Convair Division

[redacted]

A2136-1 (REV. 5-65)

GPO PRICE $ ____________

CFSTI PRICE(S) $ ____________

Hard copy (HC) 6.00

Microfiche (MF) 1.25

ff 653 July 65

GDC-BNZ65-034

OPERATIONAL CONFIGURATION DATA FOR CENTAUR GSE AND FACILITIES

VOLUME II

ELECTRICAL AND ELECTRONIC SYSTEMS

30 December 1965

Contract No. NAS3-3232

Change Order 567

Prepared for

Lewis Research Center, NASA

by

General Dynamics Convair
Launch Vehicle Programs

B. R. Foushee

B. R. Foushee, Chief
Systems Analysis

GENERAL DYNAMICS
CONVAIR DIVISION
San Diego, California

TABLE OF CONTENTS
VOLUME II

PRECEDING PAGE BLANK NOT FILMED.

TABLE OF CONTENTS (Continued)
VOLUME III

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

SECTION XII

ELECTRICAL POWER AND CONTROL SYSTEMS

12.1 ELECTRICAL POWER SYSTEM

Electrical power is provided for operation of all Ground Support Equipment (GSE) and vehicle circuits during ground checkout and countdown operations. This power is supplied to the input points of the using systems at a voltage and quality compatible with system requirements.

The external power pickup points for the GSE and Centaur vehicle systems are located in the terminal enclosures in the launch and service building and in the blockhouse.

Launch complex GSE monitors and controls the power to the vehicle power system during ground operations.

The following types of power are available at the launch complex:

a. 480 volt, 3 phase, 60 cycle power. This power is distributed throughout the launch complex and is converted to 120/208 volts at various locations by 3-phase transformers.

b. 120/208 volt, 3 phase, 4 wire, 60 cycle power. This power is distributed to terminal enclosures in the launch and service building, blockhouse, umbilical tower, service tower, parking lot, and theodolite shelter for various using systems.

c. 120/208 volt, 60 cycle regulated power. This type of power is supplied to the instrumentation racks and battery chargers.

d. 28 vdc power. This power is distributed to terminal enclosures in the launch and service building and blockhouse for various using systems.

e. 7 vdc power. This power is used in the booster telemetry and RF circuits.

f. 120/208 volt, 3 phase, 4 wire, 400 cycle power. This power is supplied to the autopilot, range safety, guidance, auxiliary programming and second stage vehicle power systems. The Centaur vehicle provides its own 400 cycle a-c power from the vehicleborne static inverter.

12.1.1 VEHICLE ELECTRICAL POWER SYSTEM FUNCTION AND CONTROL. The Centaur vehicle electrical power system supplies and distributes 28 vdc power and 115 volt, 3 phase, 400 cycle a-c power to the vehicle systems. The electrical system is capable of independent operation during flight or integrated operation during ground checkout and countdown operations.

The power sent to the Centaur vehicle from the ground source is controlled by the Vehicle Power Second Stage system. This system controls the guidance system power, pyrotechnic battery heaters, autopilot a-c power, main battery heaters, power isol... battery overtime, internal command interrupt, battery preload, and vehicle inverter power. RSC battery heaters are controlled by the Second Stage RSC panel (see Section XV).

The 400 cycle a-c power used during vehicle systems checkout, countdown, and flight operations is provided by an inverter unit in the vehicle. The 28 vdc power can be selectively provided from either a ground power source during ground operations or from batteries installed in the vehicle. This selection is made by means of a power changeover switch installed in the vehicle and controlled by the Vehicle Power Second Stage system.

A block diagram of the Centaur vehicle electrical power and control system is presented in Figure 12. 1-1.

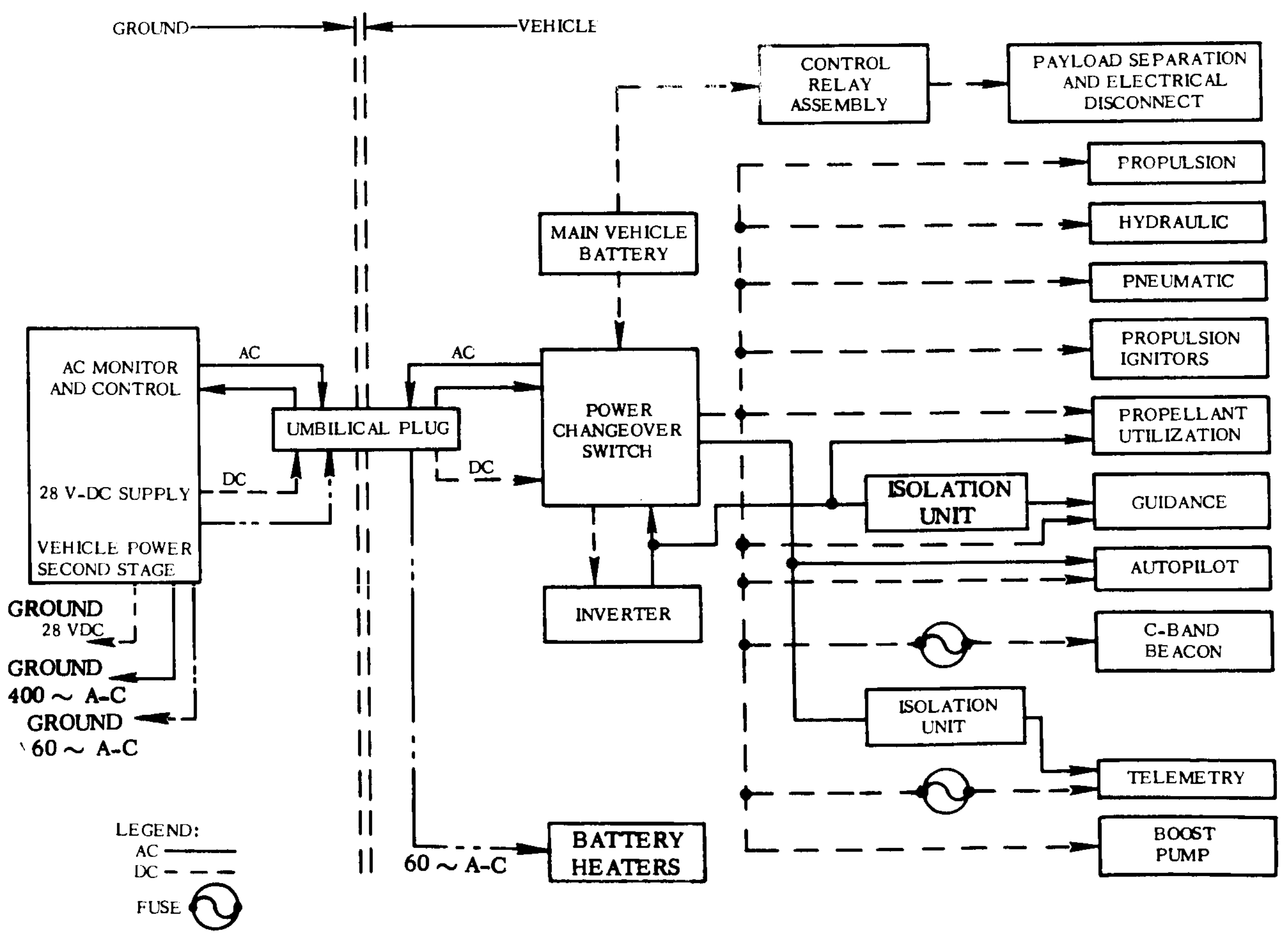


Figure 12. 1-1. Vehicle Electrical Power and Control System Block Diagram

12.1.2 VEHICLE ELECTRICAL POWER SYSTEM COMPONENTS. The vehicle-borne electrical system has an interface with the Vehicle Power Second Stage system and supplies and distributes power to the vehicle using systems. This vehicle electrical system contains the following major components:

a. Main Vehicle Battery. The main vehicle battery supplies d-c power to the systems shown in Figure 12.1-1. The main battery is a manually activated silver-oxide zinc type, dry-charged for ready availability. The electrolyte is potassium hydroxide (KOH). The battery is ready for use four hours after the electrolyte has been added.

b. Nose Fairing Pyrotechnic Batteries. These batteries are manually activated silver-oxide zinc type, dry-charged units. The electrolyte is potassium hydroxide (KOH). Figure 12.1-2 is a block diagram of the nose fairing pyrotechnic system.

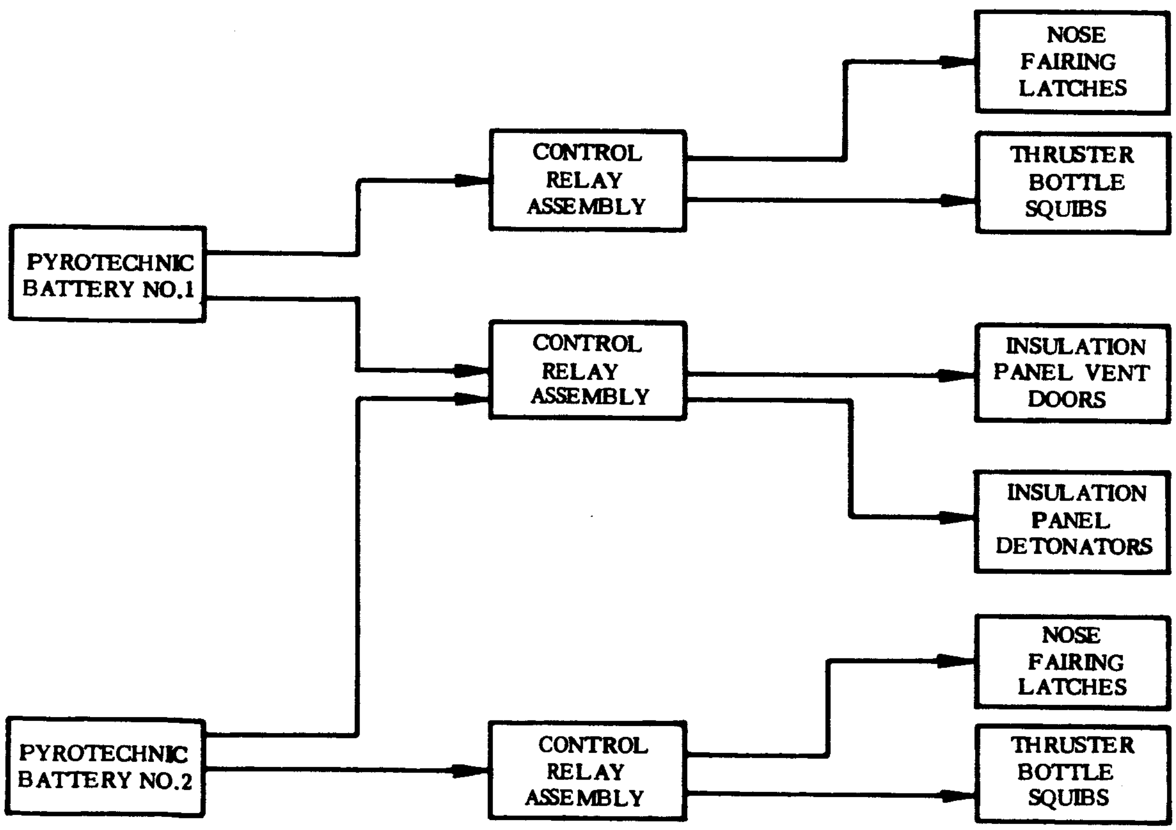


Figure 12.1-2. Nose Fairing Pyrotechnic System Block Diagram

c. Range Safety Command Batteries. These two identical batteries are manually activated silver-oxide zinc type, dry-charged units. These batteries use KOH as an electrolyte and independently supply required power to the range safety system receivers, as shown in Figure 12. 1-3.

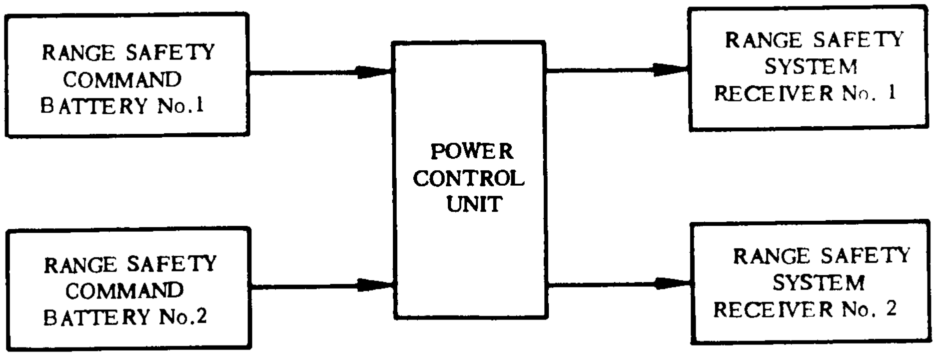


Figure 12. 1-3. Range Safety Command Battery Systems Block Diagram

d. Inverter. The vehicleborne source of a-c power is a solid state inverter which converts the 28 vdc power supplied by the main vehicle battery or the ground source to 115 volt, 3 phase, 400 cps a-c power. This power is provided to the guidance, autopilot, telemetry, and propellant utilization systems during checkout, countdown, and flight. A block diagram of the inverter is shown in Figure 12. 1-4.

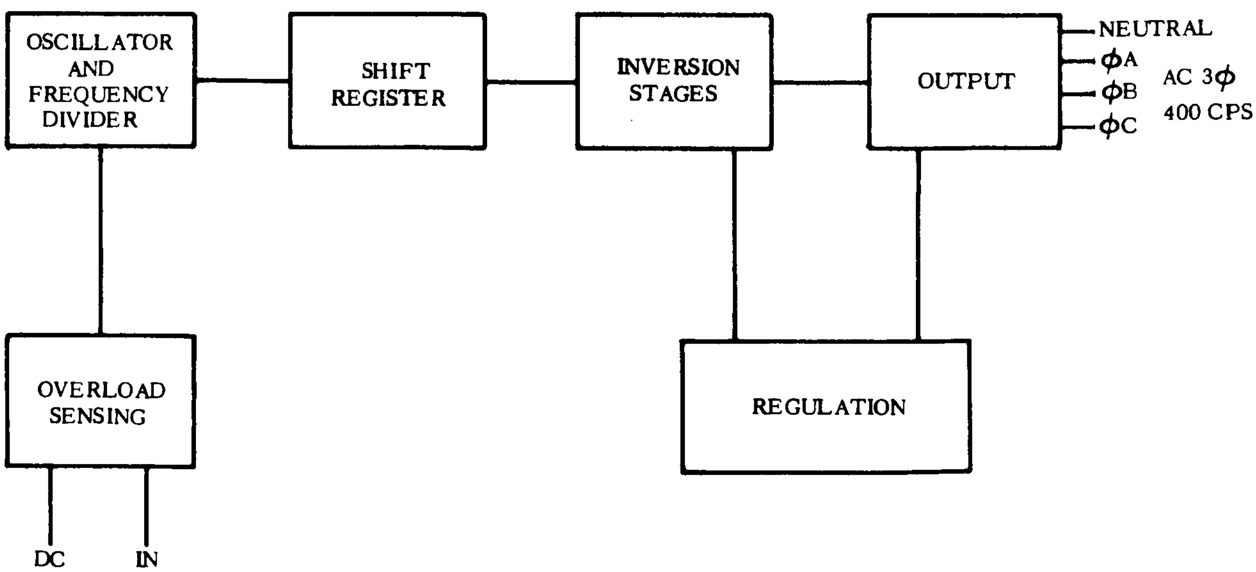


Figure 12. 1-4. Inverter Block Diagram

e. Main Power Changeover Switch. The main power changeover switch consists of a main and a secondary switch which provide for the switching from a ground power source to the vehicle 28 vdc battery systems or vice versa. The circuit diagram of the main power changeover switch is shown in Figure 12.1-5.

f. Centaur/Booster Electrical Interface. The Centaur/Booster electrical interface consists of a cable connector and wiring through which electrical signals can be exchanged for inflight control and stage separation initiation. The Centaur stage is electrically independent in that it has its own primary a-c and d-c power sources and requires no electrical support from the booster stage. The booster provides the power for stage separation and insulation panel jettison signals.

g. Centaur/Payload Interface. The Centaur/payload electrical interface supplies required signals from the Centaur stage to the payload. Electrical power from Centaur initiates pyrotechnic squib firing and stage separation sequences as may be required.

h. Centaur/GSE Interface. The Centaur/GSE interface consists of cable connector receptacles for connection with the umbilical plugs. All electrical signals exchanged between the vehicle systems and the ground systems, excepting telemetry and other RF signals, pass through this interface. The umbilical plug ejections are initiated during the launch countdown by 28 vdc signals from the launch control system logic sequence. The electrical eject signals are backed up by mechanical lanyard pull systems.

12.1.3 VEHICLE ELECTRICAL POWER GROUND CONTROL SYSTEMS COMPONENTS. The Vehicle Power Second Stage system controls the power sent to the vehicle from the ground power source. The control of power application is exercised through a control panel (see Figure 12.1-6) located in the blockhouse.

Facilities for monitoring elapsed operating times of the vehicle batteries are furnished by a Second Stage Monitors panel (see Figure 12.1-7). A block diagram of the Vehicle Power Control system is presented in Figure 12.1-8. Functional descriptions of all control switches and indicator lights located on the Vehicle Power Second Stage control panel are given in Table 12.1-1.

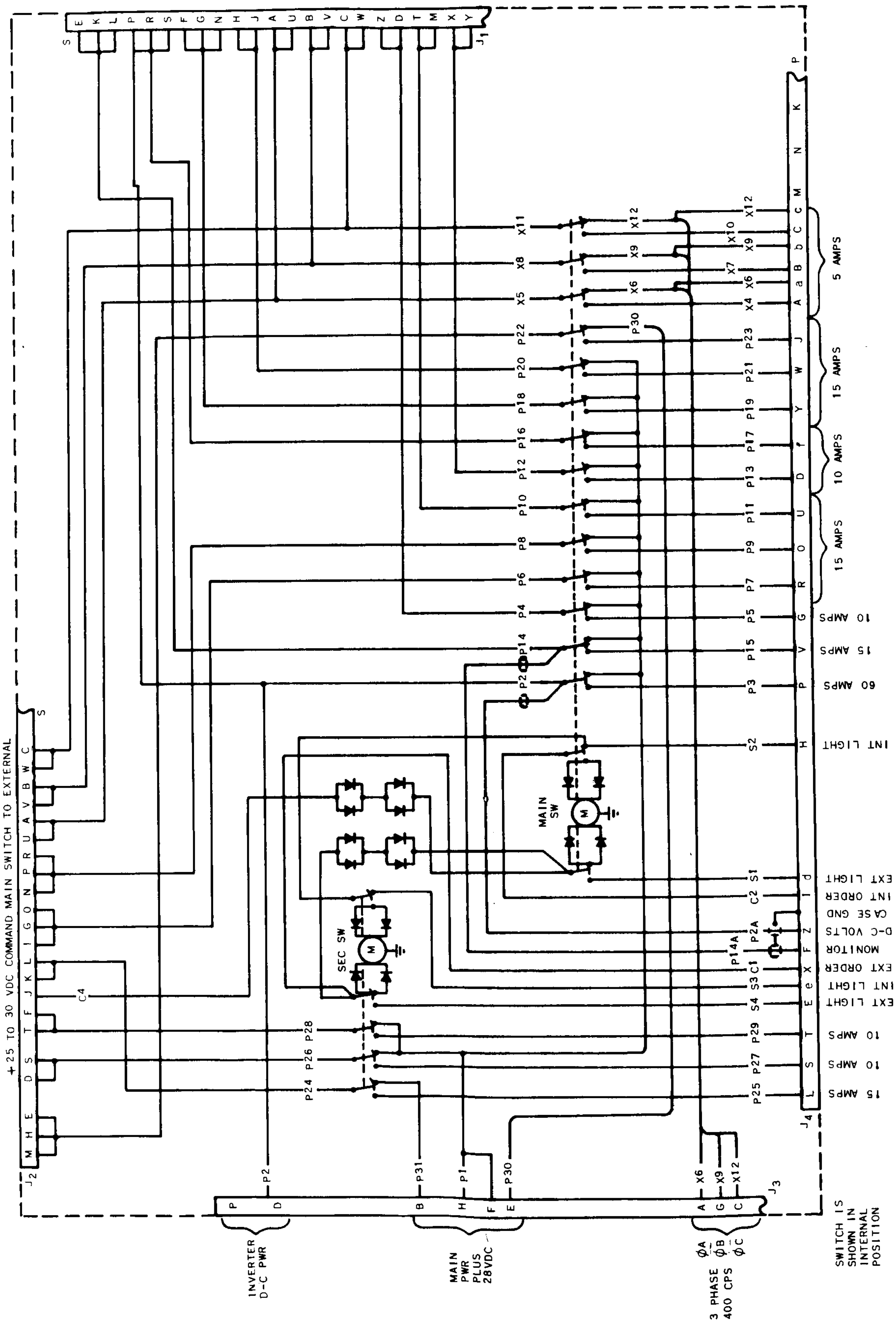


Figure 12. 1-5. Main Power Changeover Switch Circuit Diagram

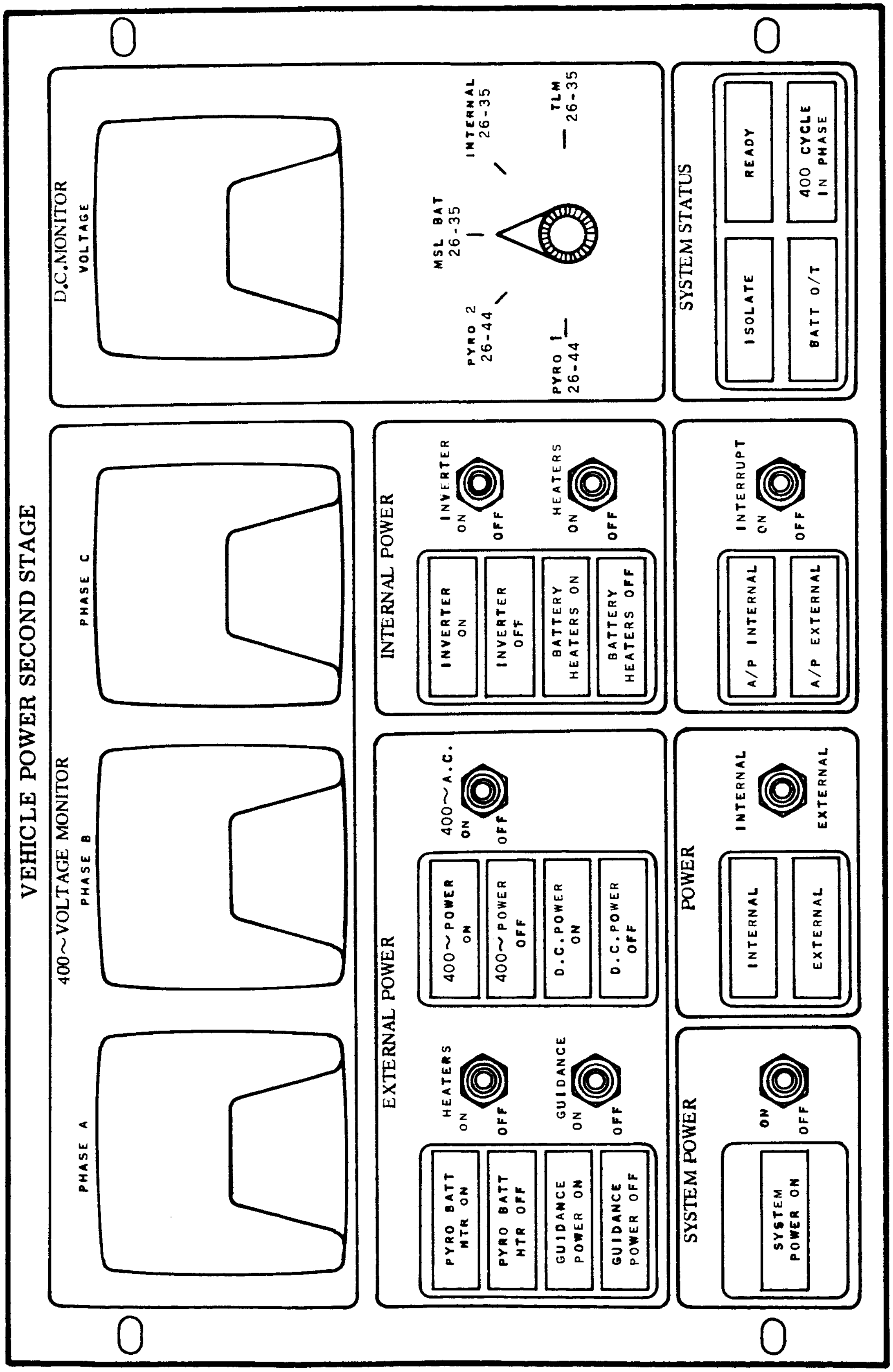


Figure 12.1-6. Vehicle Power Second Stage Control Panel

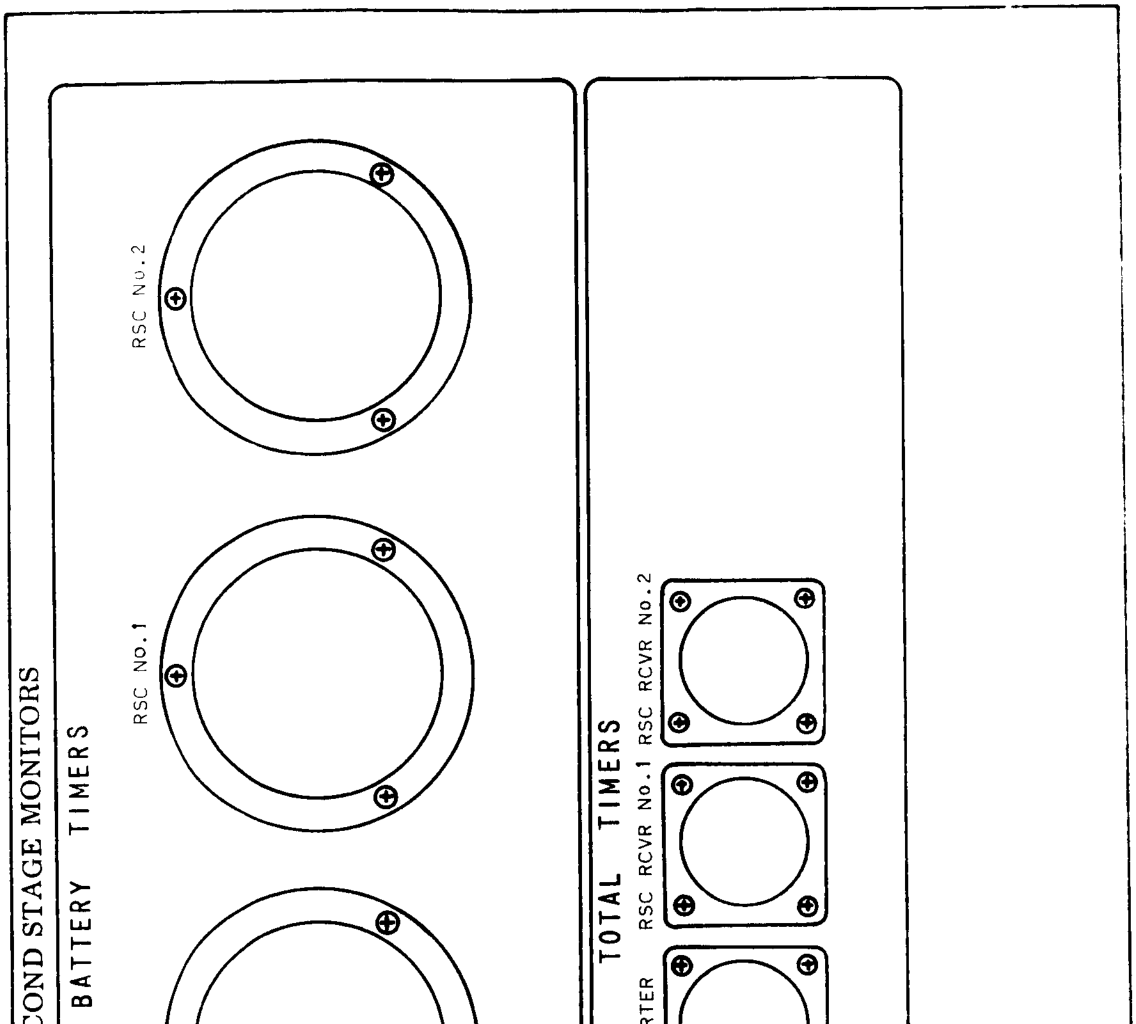


Figure 12.1-7. Second Stage Monitors Control Panel

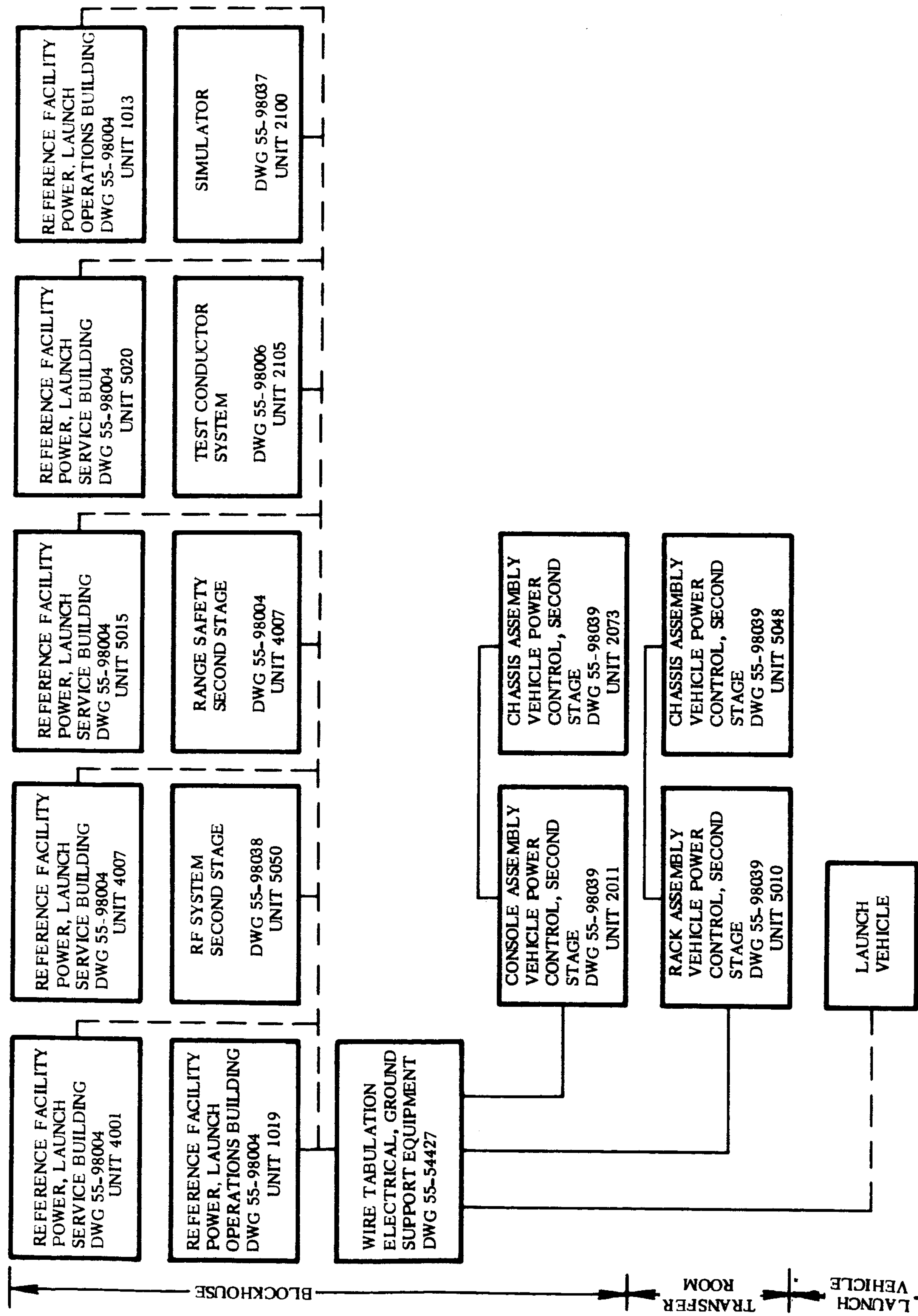


Figure 12.1-8. Second Stage Vehicle Power Control System Block Diagram

TABLE 12.1-1. FUNCTIONAL DESCRIPTION OF CONTROL SWITCHES AND INDICATOR LIGHTS, VEHICLE POWER, SECOND STAGE PANEL

In the following description, all control switches and indicator lights are located on the Second Stage Vehicle Power Control panel situated in the blockhouse control room.

Control or Indicator	Function
SYSTEM POWER Switch	Putting switch in ON position supplies 28 vdc control power to control panel and illuminates DS1 to indicate that system power is on.
GUIDANCE Power Switch	Controls guidance power to the vehicle and controls DS2 (OFF) and DS3 (ON) through appropriate circuitry.
Pyro Battery HEATERS Switch	Putting switch in ON position sends 60 cycle power to the pyro battery heaters. Also controls DS4 (OFF) and DS5 (ON) through appropriate circuitry. The pyro battery heater power is supplied only by ground power and does not require isolation.
Autopilot 400 ~ A-C Power Switch	Controls autopilot a-c power to the vehicle and also controls DS6 (ON) and DS7 (OFF) through appropriate circuitry. 28 vdc is supplied to the Autopilot A-C Power switch through a phase sensing relay when all three phases are in the correct phase relationship.
Autopilot D-C Loads Control	D-C loads are controlled by a relay which is energized by the Autopilot A-C Power relay. This relay controls DS9 (OFF) and DS10 (ON) through appropriate circuitry.
Battery HEATERS Switch	Putting switch in "ON" position supplies 115 volt, 60 cycle power to the battery heaters and also controls DS15 (ON) and DS16 (OFF) through appropriate circuitry.
POWER Change-Over Switch	Transfers power between external and internal. When the switch is thrown to EXTERNAL, it energizes a relay which sends the EXTERNAL command to the vehicle through appropriate circuitry. When thrown to INTERNAL, it energizes a relay through a permit ladder consisting of Autopilot D-C Power On, Inverter On, Internal Command Interrupt 'NOT,' and

TABLE 12. 1-1. FUNCTIONAL DESCRIPTION OF CONTROL SWITCHES AND INDICATOR LIGHTS, VEHICLE POWER, SECOND STAGE PANEL (Continued)

Control or Indicator	Function
POWER Change-over Switch (Continued)	locks up with its own contacts. The INTERNAL command is then sent to the vehicle. This switch also controls DS10 (INTERNAL) & DS11 (EXTERNAL), and DS12 (A/P EXTERNAL) & DS13 (A/P INTERNAL) through appropriate circuitry.
Power Isolate Control	Isolation of ground power from the vehicle is accomplished by removal of signals from Vehicle Power, Telemetry, and RF. A control is also provided to illuminate DS19 (ISOLATE).
Battery Overtime	This circuit consists of an arrangement of normally open contacts of the main battery timer. This timer is started by internal indication. When the timer TIMES OUT, a microswitch actuated by a cam closes and illuminates DS18 (BATTERY O/T).
INVERTER Switch	Putting switch in ON position supplies 28 vdc to the vehicle to run the inverter. The switch also controls DS16 (OFF) and DS17 (ON) through appropriate circuitry.
SYSTEM POWER ON Indicator	This indicator lights green when the System Power switch is in the ON position.
GUIDANCE POWER OFF Indicator	This indicator lights amber when the Guidance Power switch is in the OFF position.
GUIDANCE POWER ON Indicator	This indicator lights green when the Guidance Power switch is in the ON position.
PYRO BATT HTR OFF Indicator	This indicator lights amber when the Pyro Battery HTR switch is in the OFF position.
PYRO BATT HTR ON Indicator	This indicator lights green when the Pyro Battery HTR switch is in the ON position.
400 CYCLE IN PHASE Indicator	This indicator lights green when 400 cycle power is in the proper phase rotation.

TABLE 12.1-1. FUNCTIONAL DESCRIPTION OF CONTROL SWITCHES AND INDICATOR LIGHTS, VEHICLE POWER, SECOND STAGE PANEL (Continued)

Control or Indicator	Function
AUTOPILOT A-C 400 CYCLE POWER ON Indicator	This indicator lights green when the Autopilot A-C 400 Cycle Power is on and 400 cycle power is in the proper phase rotation.
AUTOPILOT A-C 400 CYCLE POWER OFF Indicator	This indicator lights amber when the 400 Cycle Power is off or 400 cycle power is not in the proper phase rotation.
D.C. POWER OFF Indicator	This indicator lights amber when the Autopilot A-C Loads light is amber.
D.C. POWER ON Indicator	This indicator lights green to indicate that D-C Loads are being supplied to the vehicle. It will light only if the vehicle is being supplied with external power.
BATTERY HEATERS ON Indicator	This indicator lights green when the Battery Heaters switch is in the "ON" position.
BATTERY HEATERS OFF Indicator	This indicator lights amber when the Battery Heaters switch is in the "OFF" position.
System READY Indicator	This indicator lights green at the same time that the Power Internal indicator lights green.
POWER INTERNAL Indicator	This indicator lights green after a signal is sent from the vehicle indicating that the vehicle is operating on internal power.
POWER EXTERNAL Indicator	This indicator lights amber after a signal is sent from the vehicle indicating that the vehicle is operating on external power.
Power ISOLATE Indicator	This indicator lights green when signals are removed from Vehicle Power and Telemetry Power Isolate Circuit.
BATTERY O/T Indicator	This indicator lights red when Battery Timer TIMES OUT.
INVERTER OFF Indicator	This indicator lights amber when the inverter is off.
INVERTER ON Indicator	This indicator lights green only when the inverter is supplied by external power.
PHASE A Meter	This is an a-c voltmeter which measures phase A voltage.

TABLE 12.1-1. FUNCTIONAL DESCRIPTION OF CONTROL SWITCHES AND INDICATOR LIGHTS, VEHICLE POWER, SECOND STAGE PANEL (Continued)

Control or Indicator	Function
PHASE B Meter	This is an a-c voltmeter which measures phase B voltage.
PHASE C Meter	This is an a-c voltmeter which measures phase C voltage.
D.C. MONITOR VOLTAGE Switch	This switch selects Pyro Battery 1 and 2 Voltages, Main Missile Battery Voltage, Internal D-C Voltage, and Telemetry Battery Voltage to be monitored by Meter 4.
D.C. MONITOR VOLTAGE Meter	This voltmeter monitors Pyro Battery 1 and 2 voltages, Main Missile Battery Voltage, Internal D-C Voltage, and Telemetry Battery Voltage.
A/P EXTERNAL Indicator	This indicator illuminates amber when the secondary changeover switch is in the external position.
A/P INTERNAL Indicator	This indicator illuminates green when the primary and secondary changeover switches are in the internal position.
Internal Command INTERRUPT Switch	This switch is operated during testing and is thrown prior to the end of the "ON BOARD" programmer run to remove internal command signal to the primary changeover switch and to allow the on-board programmer to operate the switch to the external position.

12.1.4 VEHICLE ELECTRICAL POWER AND GROUND CONTROL SYSTEMS CHECKOUT. Approved and published procedures exist for checkout of power and ground control systems.

12.1.4.1 Vehicle Electrical Power System Checkout. This procedure provides instructions for checking the vehicle power system. Main battery and pyrotechnic heater circuits are checked for proper operation. The power change-over switch and vehicle inverter voltage and frequency regulation are evaluated using a battery simulator harness in place of primary batteries for 28 vdc power. Voltage and frequency readings are evaluated in terms of tolerances specified in the procedure. All vehicle systems are affected by this test and must be in a test-ready status prior to the start of checkout.

12.1.4.2 Vehicle Electrical Power Ground Control System Checkout This procedure provides instructions for the functional checkout of the Vehicle Power Second Stage control system. The interface between the control system and associated systems is functionally checked. The following GSE is involved in this checkout:

a. Console Assembly - Vehicle Power

b. Rack Assembly - RF Auxiliary Equipment

c. Chassis Assembly - Monitor

d. Rack Assembly - Vehicle Power

e. Chassis Assembly - Vehicle Power Control

f. Interconnecting cables

g. Terminal Board Wiring Tabulation - Primary System wires.

12.1.5 GROUND POWER FUNCTION AND CONTROL. All GSE and vehicle circuits are supplied with electrical power from a ground power source during checkout and countdown operations prior to vehicle launch. (The vehicleborne static inverter supplies the Centaur vehicle with 400 cycle a-c power.) This electrical system furnishes 60 cycle a-c power, 400 cycle a-c power, and d-c power. This power is supplied to the using systems at a voltage and quality that is compatible with system requirements.

The distribution and control of the ground power system is supplied by various components of the GSE.

12.1.5.1 60 Cycle Power. The 60 cycle power sources and associated distribution equipment are furnished and installed by the facility contractor. Distribution is from two primary 13.2kv, 60 cycle sources; an industrial (commercial) and a critical (base generated) source. The 60 cycle power is distributed throughout the launch site at 480 volts and is converted to 120/208 volts at various locations by 3-phase transformers. The 60 cycle power distribution is presented in a single line diagram in Figure 12.1-9. For reference, GD/C Drawing No. 55-98001 may be consulted for an elementary schematic of the 60 cycle a-c power distribution.

A 60 cycle power control panel (see Figure 12.1-10) is located in the blockhouse. This panel provides for on-off control of the 60 cycle power to specific equipment items. Also, a meter is provided for monitoring of source voltages; and panel lights indicate power-ready status for this equipment. Transfer of selected loads from either an industrial or a critical power source to an emergency source (a diesel generator located at the launch site blockhouse)is automatic upon failure of the normal power source. A load transfer between 60 cycle facility sources is accomplished by the Range Contractor, (Pan American Airlines).

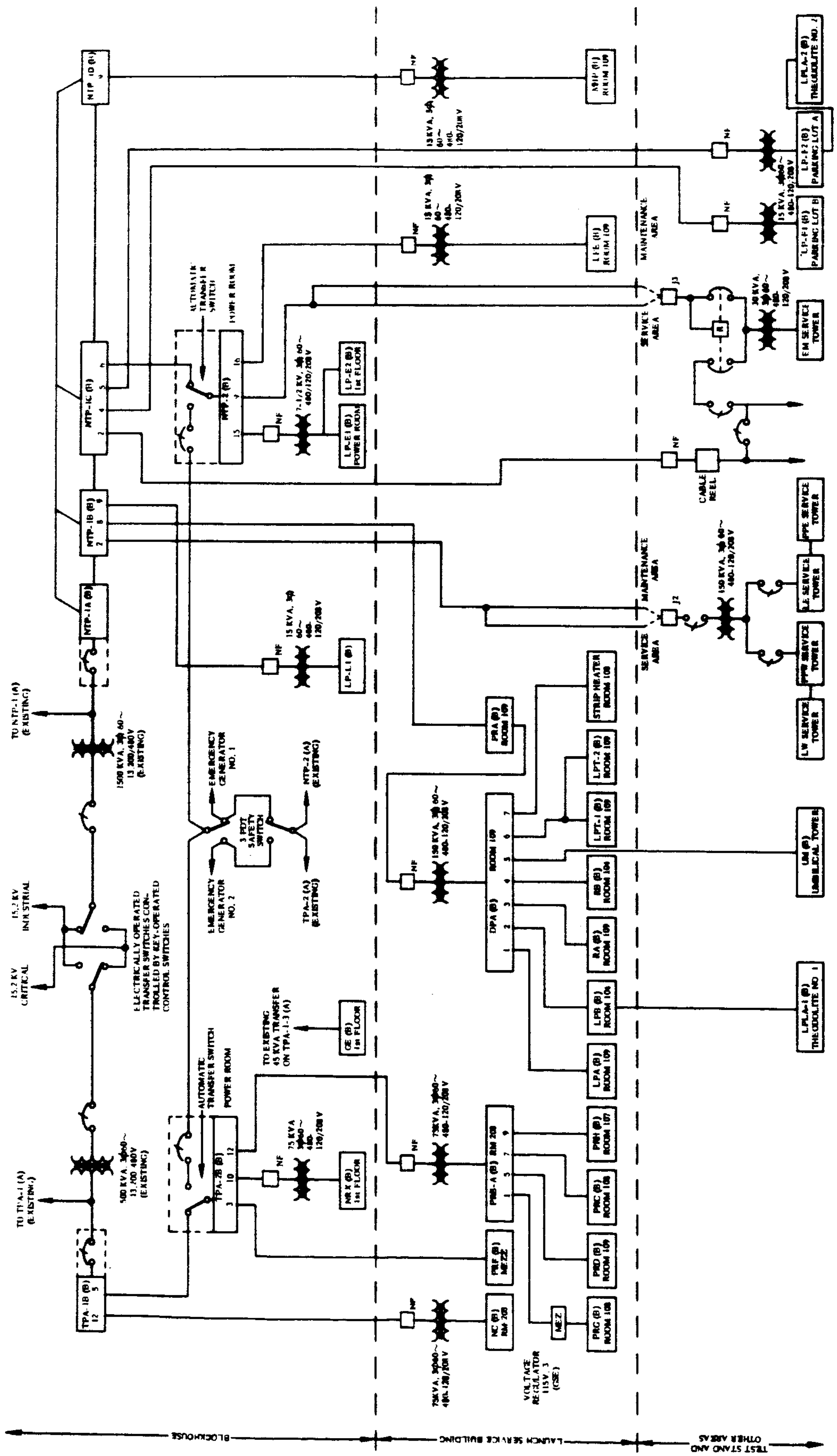


Figure 12.1-9. Single Line 60-Cycle Power Distribution Schematic Diagram

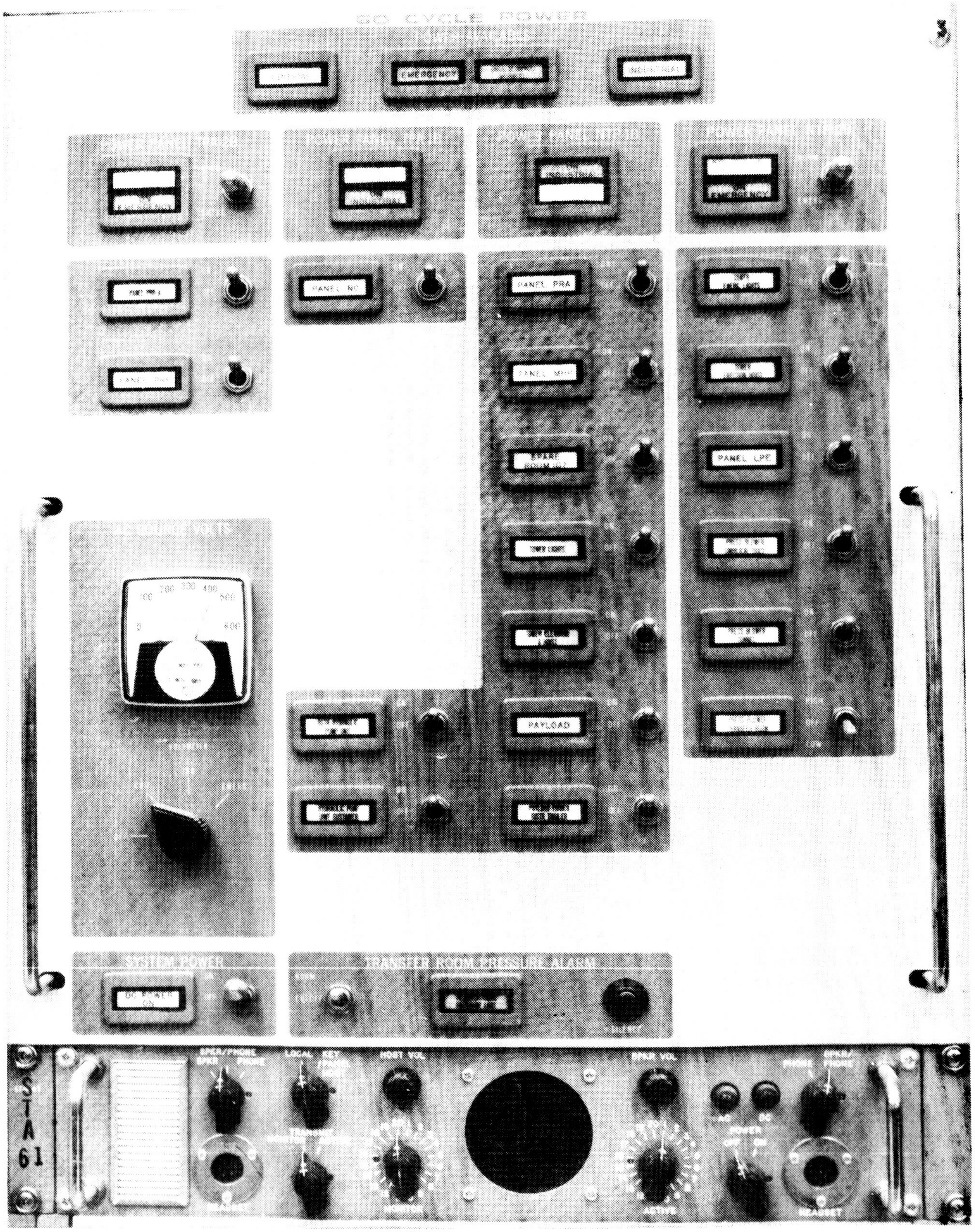


Figure 12.1-10. Sixty-Cycle A-C Power Panel

A 60 cycle power source with voltage regulated at 120±1% volts is provided through a distribution panel in the launch service building. For reference, GD/C Drawing No. 55-98002 may be consulted for an elementary schematic of the 60 cycle ac power control.

12.1.5.2 28 VDC Power. A nominal 28 vdc power source is provided for the various ground equipment and vehicle equipment items. This power is furnished by two separate 600 ampere power supplies. The main 28 vdc power supply is located in the launch service building. A backup 28 vdc power supply is located in the blockhouse. Each of these supplies has a 200 ampere-hour backup battery constantly floating on the d-c bus. The purpose of these batteries is to supply uninterrupted emergency power in case of d-c supply failure, until the alternate supply can be switched onto the d-c bus. A transfer from main supply to backup supply, or vice versa, is accomplished by the use of manually operated control switches on the 28 vdc power control panel (see Figure 12.1-11). This panel is a part of the d-c and 400 cycle a-c power control console, which is located on the blockhouse operations floor. For reference, GD/C Drawing No. 55-98003 may be consulted for an elementary schematic of the d-c power control system.

The distribution of 28 vdc power to the various systems is accomplished through two power distribution cabinets. One cabinet is located in the launch service building and the other is located in the blockhouse. The 28 vdc power busses in both distribution cabinets are connected together to form a common 28 vdc main bus. A circuit breaker and a contactor are provided between each power supply and the main bus. Each 28 vdc power supply output is placed on or off the main power bus by control of the contactor for that supply. The contactors are controlled by switches on their respective control panels.

Individual system 28 vdc busses are fed from the main bus through system power contactors. The system power contactors are controlled by switches on the respective system control chassis or consoles. Each system load is fed from the system bus through circuit breakers located in the distribution cabinets (terminal enclosures). From the terminals in the distribution cabinets, each system (both ground and vehicle systems) is supplied with power as required.

The 28 vdc distribution system is shown in Figure 12.1-12. A one-line schematic diagram of the distribution system is shown in Figure 12.1-13, which presents both the 28 vdc and 7 vdc distribution. For reference, GD/C Drawing No. 55-98004 may be consulted for an elementary schematic of the d-c power distribution.

The 28 vdc power supplies have an adjustable range of 26 to 30 volts and are regulated to 29.5 volts sensed at the distribution cabinets. Static regulation is ± 1 percent, and dynamic regulation is ± 4 volts with a 50 percent load change. The batteries for the backup supply are a lead-acid type, rated at 200 ampere-hours.

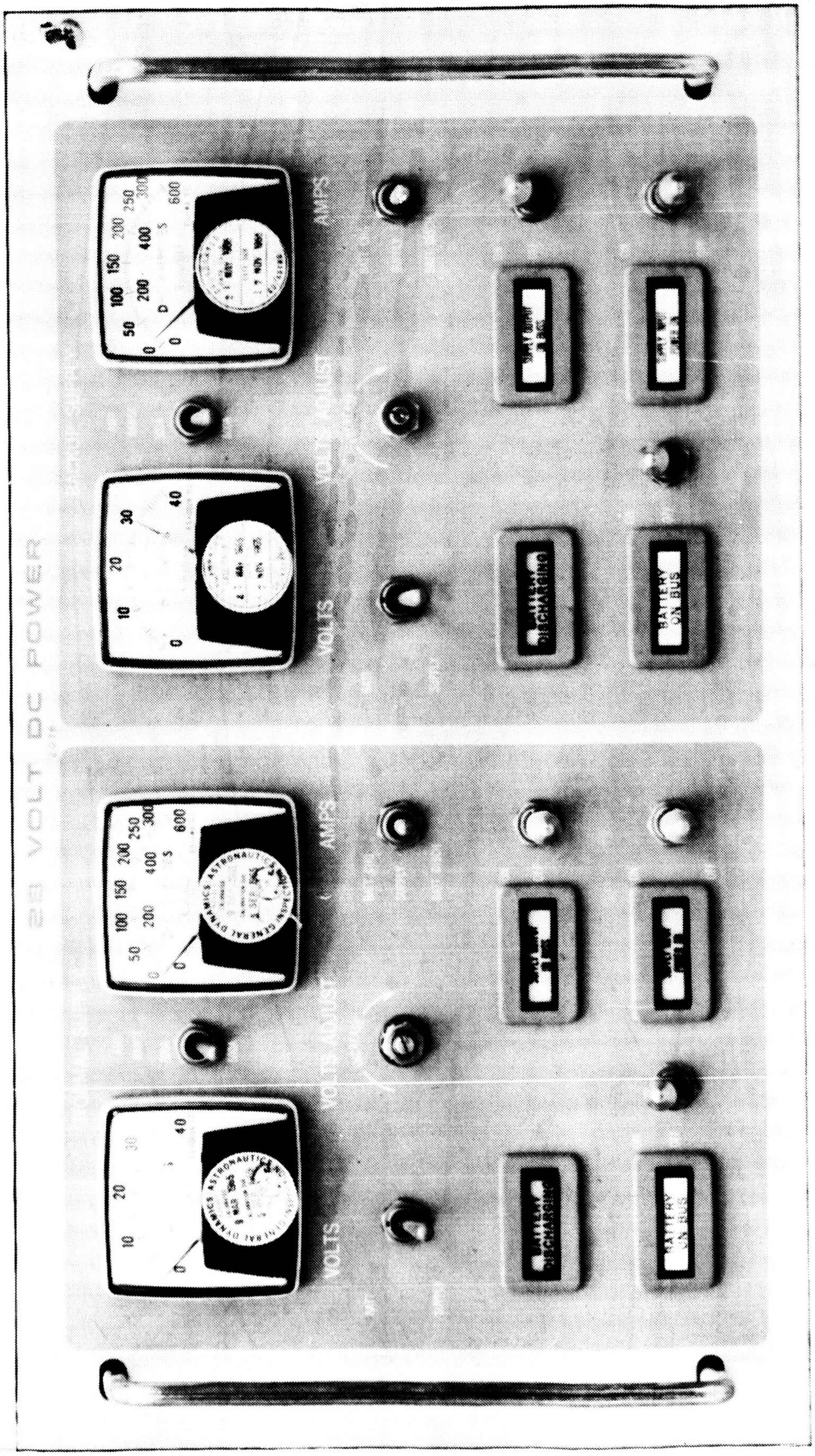


Figure 12.1-11. 28 VDC Control Panel

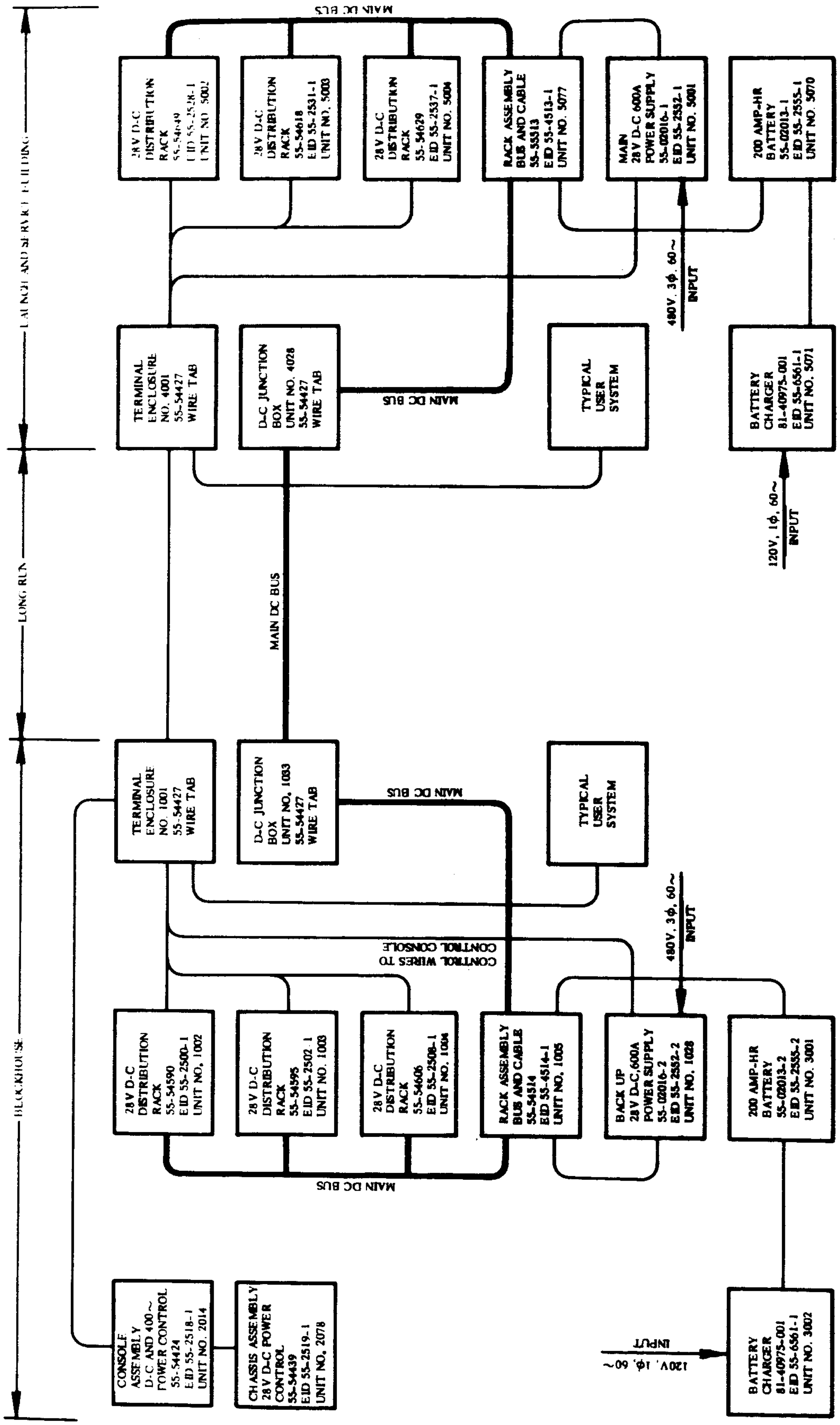


Figure 12.1-12. Block Diagram, 28 VDC Distribution System

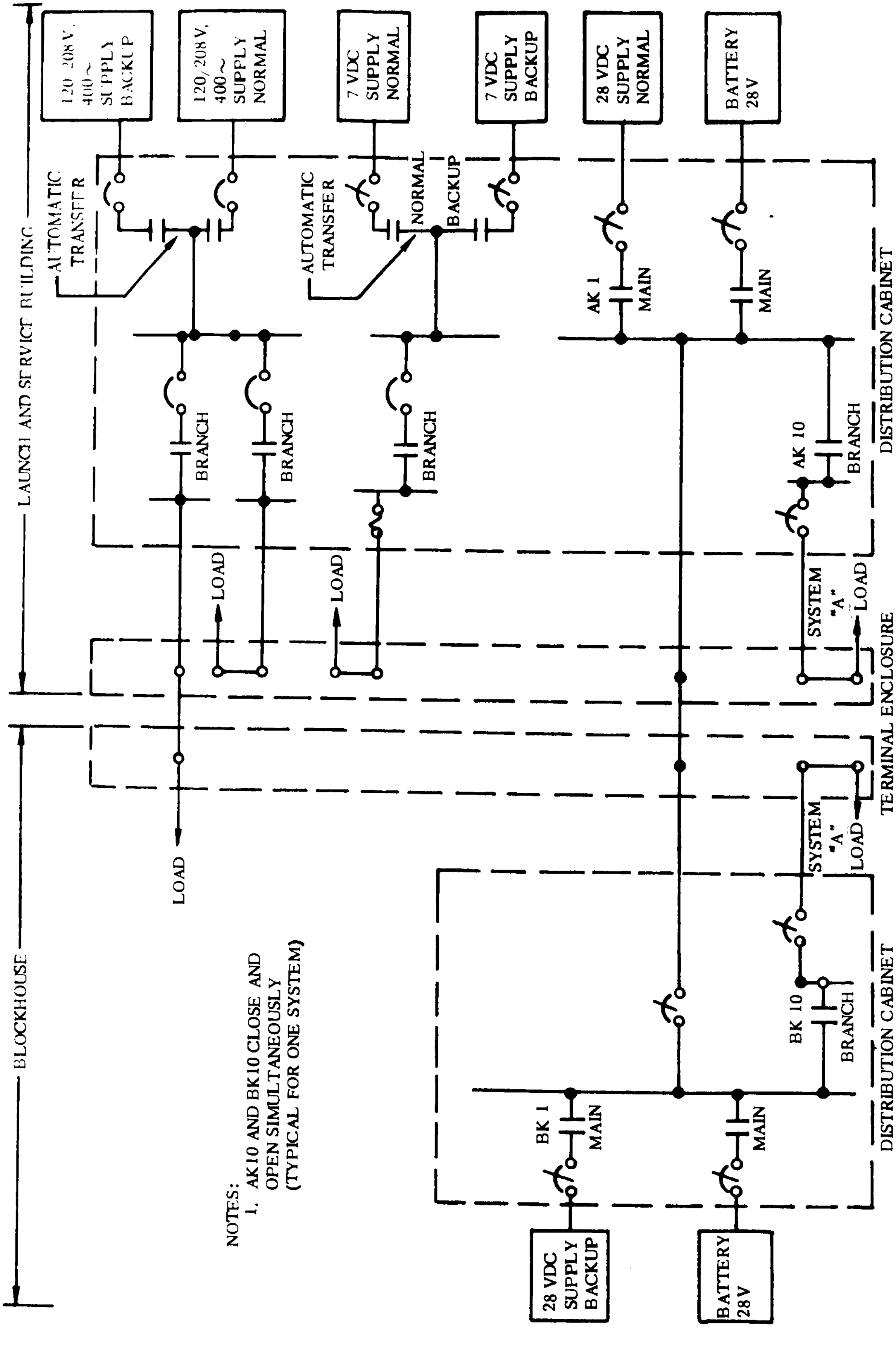


Figure 12.1-13. Schematic Diagram, D-C and 400-Cycle A-C Distribution

12.1.5.3 7 VDC Power. Two 7 vdc power supplies are located on the mezzanine floor of the launch service building. One is used as a normal supply and one as a backup supply. Application of the backup supply to the load terminals occurs automatically upon loss of the normal supply voltage. Both 7 vdc supplies provide regulated 7 volts regulated to within ±1 percent at their terminals. The 7 vdc control panel (see Figure 12.1-14) is a part of the d-c and 400 cycle a-c power console.

The 7 vdc power supplies have a 5.5 to 7 volt adjustable range and are regulated by remote sensing leads at the distribution cabinet located in the launch service building. Static regulation is ±1 percent.

12.1.5.4 400 Cycle Power. Two 120/208 volt, 3 phase, 400 cycle power supplies are located in the launch service building. One supply is used as a backup and application of this supply to the load is automatic upon loss of the normal source voltage. The voltage regulation is ±1 percent and the frequency regulation is ±0.25 percent. Total harmonics are less than 3 percent.

The distribution of the 120/208 volt, 400 cycle power is similar to that for the 28 vdc and 7 vdc (see Figure 12.1-13). For reference, GD/C Drawing 55-98030 may be consulted for an elementary schematic of the 400 cycle power distribution.

The 400 cycle a-c power control panel is shown in Figure 12.1-15 which is a part of the d-c and 400 cycle a-c power control console. For reference, GD/C Drawing 55-98029 may be consulted for an elementary schematic of the 400 cycle power control system.

12.1.6 PERIPHERAL TEST EQUIPMENT. A portable relay test set, two portable d-c power supplies, and two portable 400 cycle a-c power supplies are provided for performing incidental tests of components and circuits as required.

12.1.6.1 Portable Relay Test Set. A portable relay test set (P/N 55-54542-1) is provided at the launch site for on-the-job relay test capability. The test set can also be used for field adjustment of adjustable time delay relays.

The portable relay test set is contained in a weather-proof carrying case approximately 15 inches by 17 inches by 22 inches. Two cable assemblies, P/N 55-51221-1 Cable Assembly - AC Power and P/N 55-51222-1 Cable Assembly - Special Purpose Electrical, are furnished with the test set and are stored in the cover of the carrying case.

The test set control panel contains the following components:

a. Receptacle for a-c power input cable plug (J4).

b. Receptacle for special purpose test cable plug (J1).

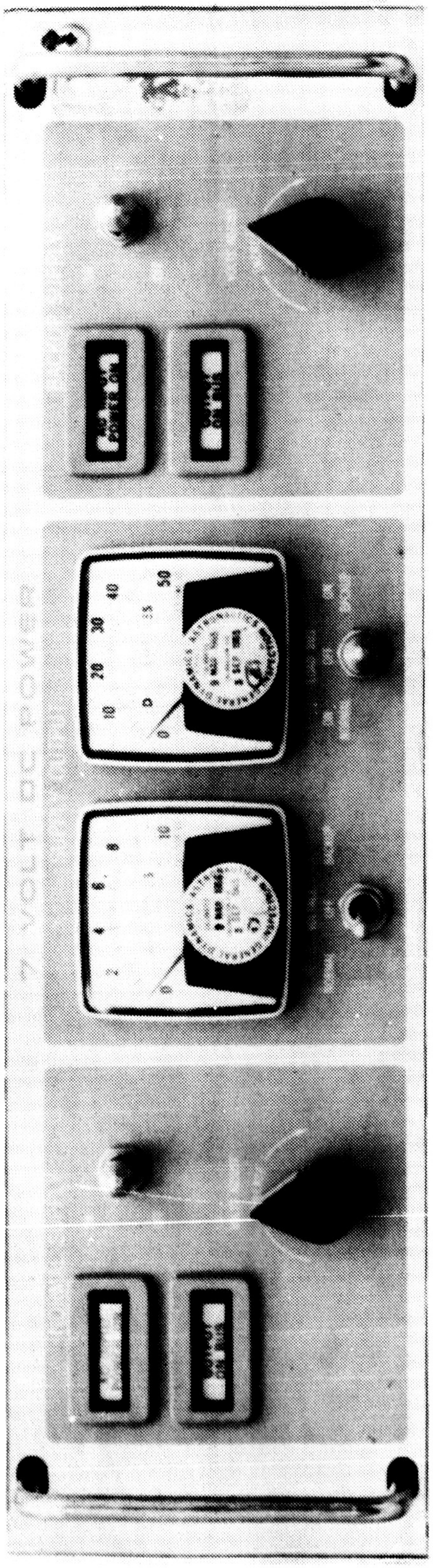


Figure 12.1-14. 7 VDC Control Panel

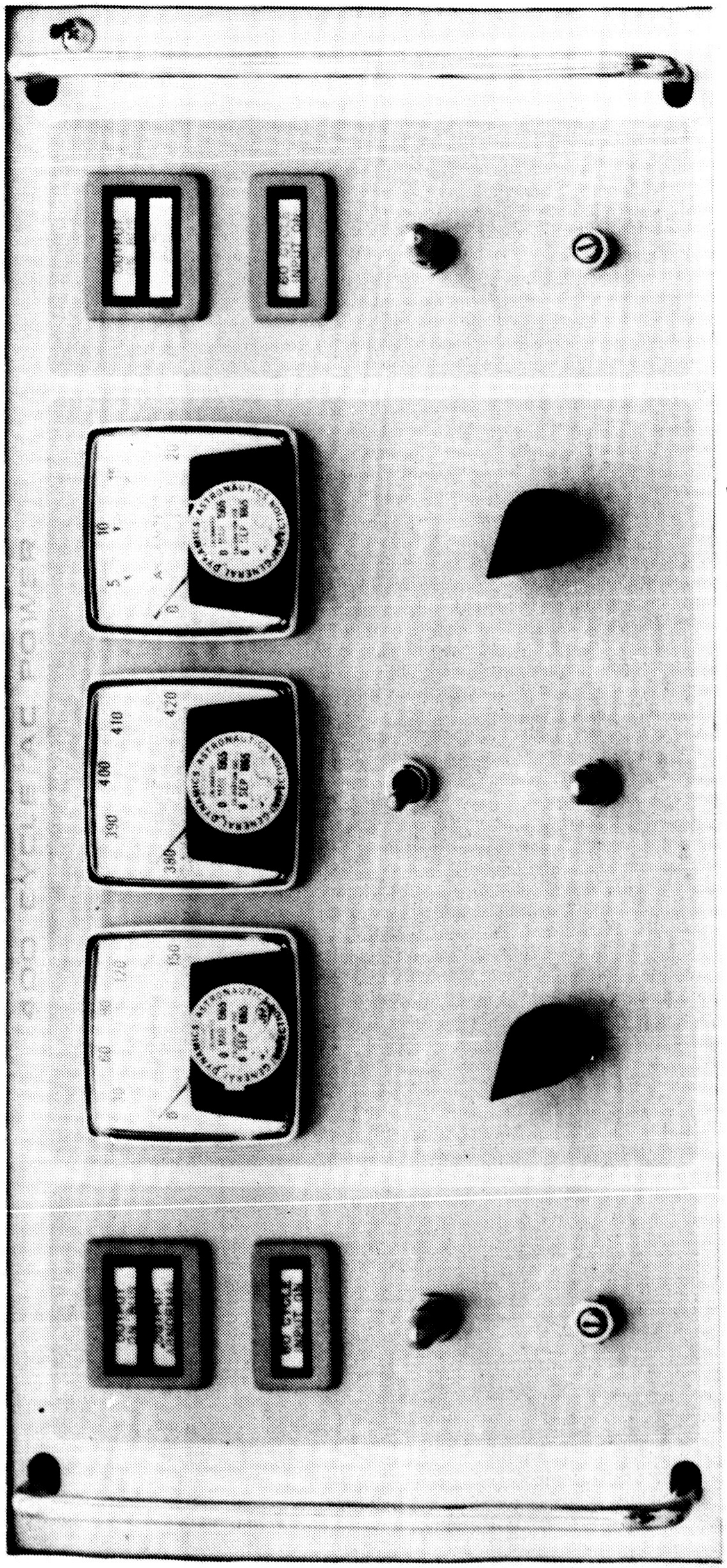


Figure 12.1-15. 400 Cycle Control Panel

c. Sockets for plug-in relays (X1, X2, X3, X4, X5, X6, X7, and X8).

d. Terminal posts (2) for external coil input (J2, J3).

e. COIL EXCITATION selector switch (EXTERNAL-INTERNAL) (S4).

f. TEST SELECTOR switch (OPERATIONAL-VOLTAGE DROP) (S1).

g. CONTACT function indicators (DS2 through DS13).

h. POWER indicator (DS1).

i. Input POWER circuit breaker (CB1).

j. A-C Voltmeter (M1).

k. A-C Coil Voltage Control (T2).

l. D-C Voltmeter (M2).

m. D-C Coil Voltage Control (R3).

n. Test Meter, millivoltmeter (contact voltage drop) (M3).

o. Relay contact selector switch (1 through 15 and OFF) (S5).

p. Millivoltmeter sensivity push button switch (0-50 mv scale) (S7).

q. TIME DELAY selector switch (S8).

r. TIMER FUNCTION selector switch (S2).

s. TEST FUNCTION selector switch (S3).

t. Relay COIL selector switch (S6).

u. Timer (CL1).

A front view of the Relay Test Set control panel is shown in Figure 12.1-16.

The following components are installed beneath the control panel of the test set:

a. Power supply, 0-30 volts dc, adjustable

b. Power supply, 12 volts dc

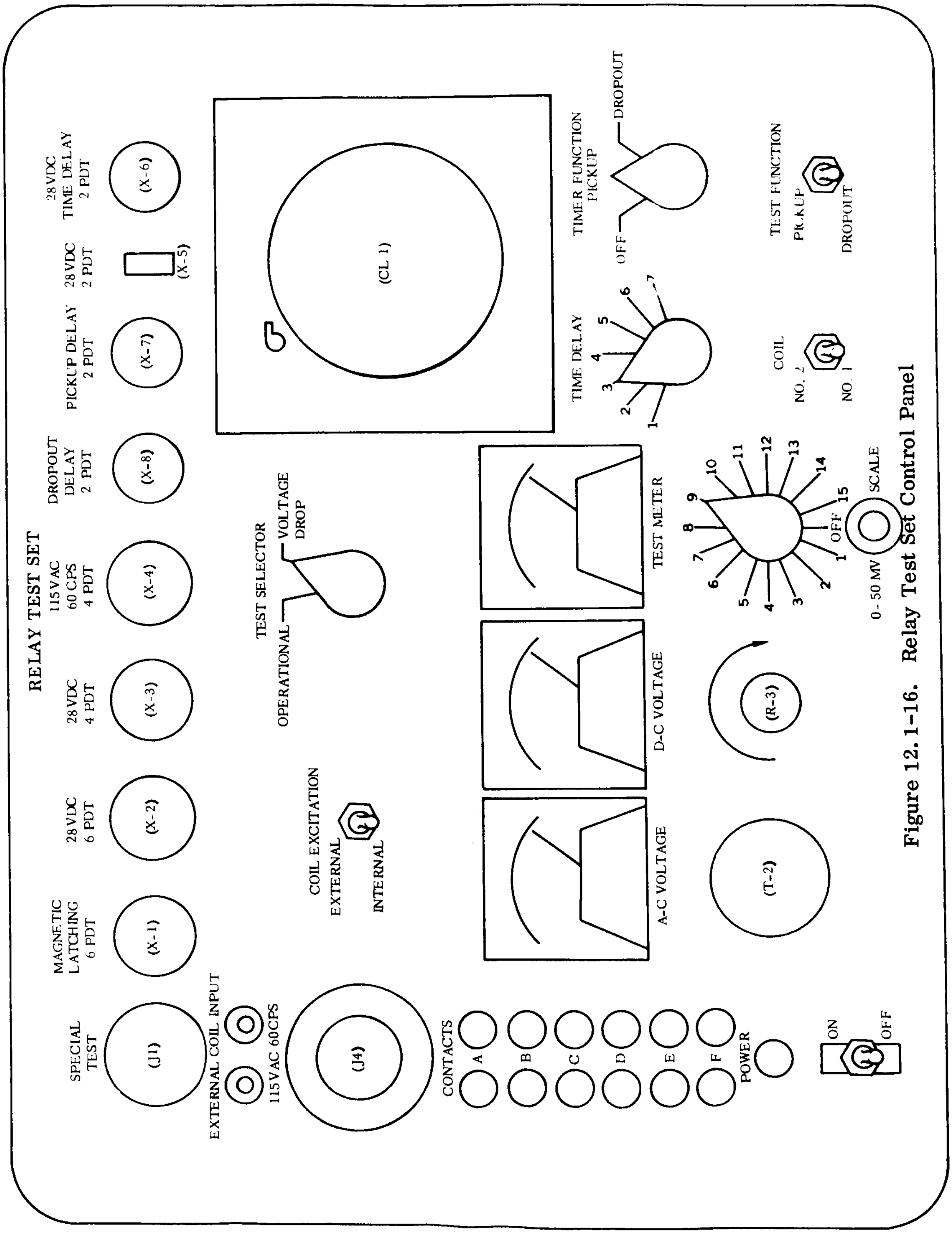


Figure 12.1-16. Relay Test Set Control Panel

c. Transformer, 24 volts ac.

d. Circuit components - diodes (2), resistors (5).

Detailed circuit diagrams may be found in GD/C Drawing No. 55-54542.

12.1.6.1.1 Function Description. The test set is powered by 115 volts, 60 cycle, single phase a-c power, supplied to the "115 VAC 60 CPS" input power receptacle from a facility power source.

Plug-in relays are inserted into the tester panel relay sockets for testing per Table 12.1-2. Other relays are connected to the test set per Table 12.1-3 by means of the special test cable which is plugged into the SPECIAL TEST receptacle. Table 12.1-4 gives the limits of the test set power supply for relay coil excitation. Only one relay at a time may be plugged in or connected to the test set.

A functional description of the switches, controls, and indicators on the Relay Test Set control panel is given in Table 12.1-5.

TABLE 12.1-2. PLUG-IN RELAYS, PORTABLE RELAY TEST SET

GD/C Part Number	Vendor Part Number/ Coil Volts, Contact Amps	Relay Type (Test Socket Name)
86-73903-003	Leach 9223-6622/28 vdc, 5a	Magnetic Latching 6 PDT
86-73900-363	Leach 9226-6718/28 vdc, 5a	28 vdc, 6 PDT
86-73900-362	Leach 9224-6717/28 vdc, 10a	28 vdc, 4 PDT
86-73900-366	Leach 9224-4488/115 vac, 60 cycle	115 vac, 60 cps, 4 PDT
--	Agastat 2122 Series/28 vdc, 10a	Dropout Delay, 2 PDT
--	Agastat 2112 Series/28 vdc, 10a	Pickup Delay, 2 PDT
86-73901-013	Potter & Brumfield SC-7460/28 vdc, 2a	28 vdc, 2 PDT
--	Tempo 9698 TDPU	28 vdc, Time Delay 2 PDT

TABLE 12.1-3. RELAY FUNCTIONS VERSUS CONNECTOR CONTACTS

Tester Light	Relay Contact	Connector Contact: Special Test Plug Contact	Special Test Test Clip	Magnetic Latching 6 PDT	28 vdc 6 PDT	28 vdc 4 PDT	115 vac 60 cps 4 PDT	Drop-Out Delay 2 PDT	Pick-Up Delay 2 PDT	28 vdc 2 PDT	28 vdc Time Delay 2 PDT
A - Amber	A1 - Norm Open	A	E1	A1	A1	A1	A1	3	4	6	6
———	A2 - Common	B	E2	A2	A2	A2	A2	2	2	4	4
A - White	A3 - Norm Closed	C	E3	A3	A3	A3	A3	4	3	5	5
B - Amber	B1 - Norm Open	D	E4	B1	B1	B1	B1	6	5	3	3
———	B2 - Common	E	E5	B2	B2	B2	B2	7	7	1	1
B - White	B3 - Norm Closed	F	E6	B3	B3	B3	B3	5	6	2	2
C - Amber	C1 - Norm Open	G	E7	C1	C1	C1	C1				
———	C2 - Common	H	E8	C2	C2	C2	C2				
C - White	C3 - Norm Closed	J	E9	C3	C3	C3	C3				
D - Amber	D1 - Norm Open	K	E10	D1	D1	D1	D1				
———	D2 - Common	L	E11	D2	D2	D2	D2				
D - White	D3 - Norm Closed	M	E12	D3	D3	D3	D3				
E - Amber	E1 - Norm Open	N	E13	E1	E1	—	—				
———	E2 - Common	P	E14	E2	E2	—	—				
E - White	E3 - Norm Closed	R	E15	E3	E3	—	—				
F - Amber	F1 - Norm Open	S	E16	F1	F1	—	—				
———	F2 - Common	T	E17	F2	F2	—	—				
F - White	F3 - Norm Closed	U	E18	F3	F3	—	—				
Coil Excitation											
	Coil No. 1 (+dc)	X	E21	X1	X1	X1	—	8	8	20	20
	Coil No. 1 (-dc)	Y	E22	X2	X2	X2	—	1	1	19	19
	Coil No. 2 (+dc)	V	E19	Y1	—	—	—	—	—	—	—
	Coil No. 2 (-dc)	W	E20	Y2	—	—	—	—	—	—	—
	Coil No. 1 (a-c "hot")						X1				
	Coil No. 1 (a-c gnd)						X2				
Contact Voltage Drop Sensing	+	Z	E23								
	-	a	E24								

TABLE 12.1-4. RELAY COIL EXCITATION LIMITS

Coil Excitation	Coil Current
0-30 vdc	0.5 amps, maximum
0-140 volts, 60 cycle ac	2.4 amps, maximum

TABLE 12.1-5. FUNCTIONAL DESCRIPTION OF SWITCHES, CONTROLS, AND INDICATORS ON THE RELAY TEST SET PANEL

Control or Indicator	Function
COIL EXCITATION Switch	Selects excitation of the relay coil from an external source via the External Coil Input jacks or from the internal power source.
TEST SELECTOR Switch	Selects OPERATIONAL test mode or VOLTAGE DROP test mode. In the OPERATIONAL test mode, the contact indicators monitor the relay contact action (white = normally closed contacts closed, amber = normally open contacts closed). In the VOLTAGE DROP test, a regulated 1 ampere current is passed through each relay contact in turn as selected by the TEST METER selector switch.
TEST METER Selector Switch	See TEST SELECTOR switch for function, and Table 12.1-6 for switch position versus relay contact.
TEST METER	Reads the contact voltage drop on a 0-500 millivolt scale, or on a 0-50 millivolt scale when the 0-50 MV SCALE push-button is pressed. The contact test current being 1 ampere, the Test Meter may be read directly in milliohms.
AC VOLTAGE Meter and Control Knob	This meter indicates voltage applied to the relay coil from the internal a-c power supply and the control knob regulates voltage to the relay coil.

TABLE 12.1-5. FUNCTIONAL DESCRIPTION OF SWITCHES, CONTROL, AND INDICATORS ON THE RELAY TEST SET PANEL (Continued)

Control or Indicator	Function
DC VOLTAGE Meter and Control Knob	This meter indicates voltage applied to the relay coil from the internal d-c power supply and the control knob regulates voltage to the relay coil.
TEST FUNCTION Switch	In the PICKUP position, power is applied to the coil of the relay under test. In the DROPOUT position, the power is removed from the relay coil.
COIL Switch	Selects which coil of a two coil relay will have power applied. For single coil relays, the switch remains in position No. 1.
TIMER	Measures the elapsed time between application of coil power and relay pickup for a time delay on the pickup relay. It also measures the elapsed time between removal of coil power and relay dropout for a time delay on the dropout relay.
TIMER FUNCTION Switch	Selects the operational mode of the timer, e.g. OFF-PICKUP-DROPOUT. The switch also connects the timer clutch solenoid to the "A" contacts of the relay under test.
TIME DELAY Selector Switch	Functional only when testing Tempo 9698 type time delay relays. Table 12.1-7 shows the switch position versus nominal relay time delay setting.

TABLE 12.1-6. TEST METER SELECTOR SWITCH POSITION VERSUS RELAY CONTACT

Test Meter Selector Switch Position	Relay Contacts	
	Pole	Contact
1	A A	1 (Norm Open) 2 (Common)
2	B B	1 (Norm Open) 2 (Common)
3	C C	1 (Norm Open) 2 (Common)
4	D D	1 (Norm Open) 2 (Common)
5	E E	1 (Norm Open) 2 (Common)
6	F F	1 (Norm Open) 2 (Common)
7	A A	3 (Norm Closed) 2 (Common)
8	B B	3 (Norm Closed) 2 (Common)
9	C C	3 (Norm Closed) 2 (Common)
10	D D	3 (Norm Closed) 2 (Common)
11	E E	3 (Norm Closed) 2 (Common)
12	F F	3 (Norm Closed) 2 (Common)
13	Meter calibration check (0.050 ohm ±2%)	

TABLE 12.1-7. TIME DELAY SELECTOR FOR TEMPO MODEL 9698 RELAY

Time Delay Switch Position	Relay Socket Contact Shorting	Relay Coarse Time Delay
1	7-10, 11-8	0.75 sec
2	7-13, 11-9	2.5 sec
3	7-13, 11-12	5.8 sec
4	7-13, 11-14	9.0 sec
5	7-16, 11-15	13.5 sec
6	7-16, 11-17	19.5 sec
7	7-16, 11-18	25.0 sec

12.1.6.1.2 Characteristics and Capability. The portable relay test set has the capability of performing the following tests:

a. Functional Test

b. Operating Voltage Test

c. Operating Time Delay Measurement

d. Contact Resistance Measurement

e. Diode Test

f. Coil Resistance Measurement.

Auxiliary equipment is required in conjunction with the Relay Test Set to accomplish the above tests. This equipment is as follows:

a. Multimeter, Simpson Model 260 or equivalent

b. Resistance bridge

c. Variable voltage power source to satisfy relay coil voltage requirements other than that supplied by the test set (Refer to Table 12.1-4).

12.1.6.1.3 Equipment Checkout. Test equipment required for checkout of the Relay Test Set consists of the following:

a. Multimeter, Simpson Model 260 or equivalent

b. Test jumper leads, No. 20 wire, 12 inches long with tips to fit relay socket contacts

c. Test jumper leads, No. 20 wire, 12 inches long with tips to accommodate clips of the special test cable (6 required).

The following components and circuits of the Relay Test Set will be checked out or tested prior to start of relay testing:

a. AC POWER circuit breaker switch and POWER indicator

b. TEST METER calibration

c. Internal power supplies, ac and dc

d. Circuit check which includes continuity checks, voltage (or no voltage) checks, and polarity of d-c power for various operational positions of the test set control panel selector switches, controls, and adjustments

e. CONTACT lights and TEST METER check, first with the TEST SELECTOR switch at OPERATIONAL and then at VOLTAGE DROP. This test starts with the special test cable clips and then is repeated for each of the test set panel relay sockets

f. Timer check with the TIMER FUNCTION switch set at PICKUP and then at DROPOUT.

12.1.6.2 Power Supply, Portable 400 Cycle AC. Two identical and portable 400 cycle a-c power supplies (P/N 55-60231-1) are available at the launch site. These supplies are used for test or checkout of GSE which is removed or isolated from a parent system. Also, these supplies are used to energize selected circuits when power is not available from the permanently installed GSE power supply equipment.

Each 400 cycle a-c power supply is contained within a single equipment rack approximately 52 inches high by 24 inches wide by 22 inches deep, and is mounted on casters for easy portability. The rack contains three identical power amplifier chassis identified as PHASE A, PHASE B, and PHASE C. An oscillator unit is installed in the front of the PHASE A power amplifier.

Each of the power amplifier front panels contains the following components:

a. Line ON switch with indicator

b. HI VOLTS indicator

c. Output ON switch with indicator

d. Overload indicator (top) and RESET switch (bottom)

e. Output binding posts

f. Output voltmeter.

The rear of each power amplifier contains the following:

a. Terminal board (upper left), power input and a-c power output

b. Line fuse

c. Bias test points

d. Terminal board (upper right), oscillator output.

The oscillator unit panel (on PHASE A amplifier only) contains an output voltage adjustment, fine and coarse.

A blower assembly for chassis cooling is mounted in the bottom of the rack. A hinged door provides access to the rear of the rack. The rack assembly includes all necessary internal wiring connections.

A front view of the 400 cycle a-c portable power supply is shown in Figure 12.1-17.

12.1.6.2.1 Functional Description. The power supply unit converts a 120 volt, 60 cycle, single phase a-c power input to single phase or 3 phase 400 cycle a-c output power. The input power is facility furnished. Output power is taken from the power output terminals located on the front panel of each power amplifier.

The power amplifiers are used individually to supply single phase power or WYE connected to supply 3 phase a-c power.

Figure 12.1-18 is a functional block diagram of the power supply. A functional description of switches, controls and indicators on the power supply amplifier panels is presented in Table 12.1-8.

12.1.6.2.2 Characteristics and Capability. The 400 cycle a-c portable power supply has the following characteristics and capability:

Input power:	117 volts ±10%, 47 to 60 cps, single phase ac
Output power:	350 volt-amperes single phase, 1000 volt-amp 3 phase, at ±0.70 power factor.
Output voltage:	0 to 130 volts ac single phase, 0 to 225 volts ac 3 phase line-to-line (output voltage adjustable).
Full power:	Available over output voltage range of 100 to 130 volts, single phase.
Output frequency:	400 cps ± 0.1%.

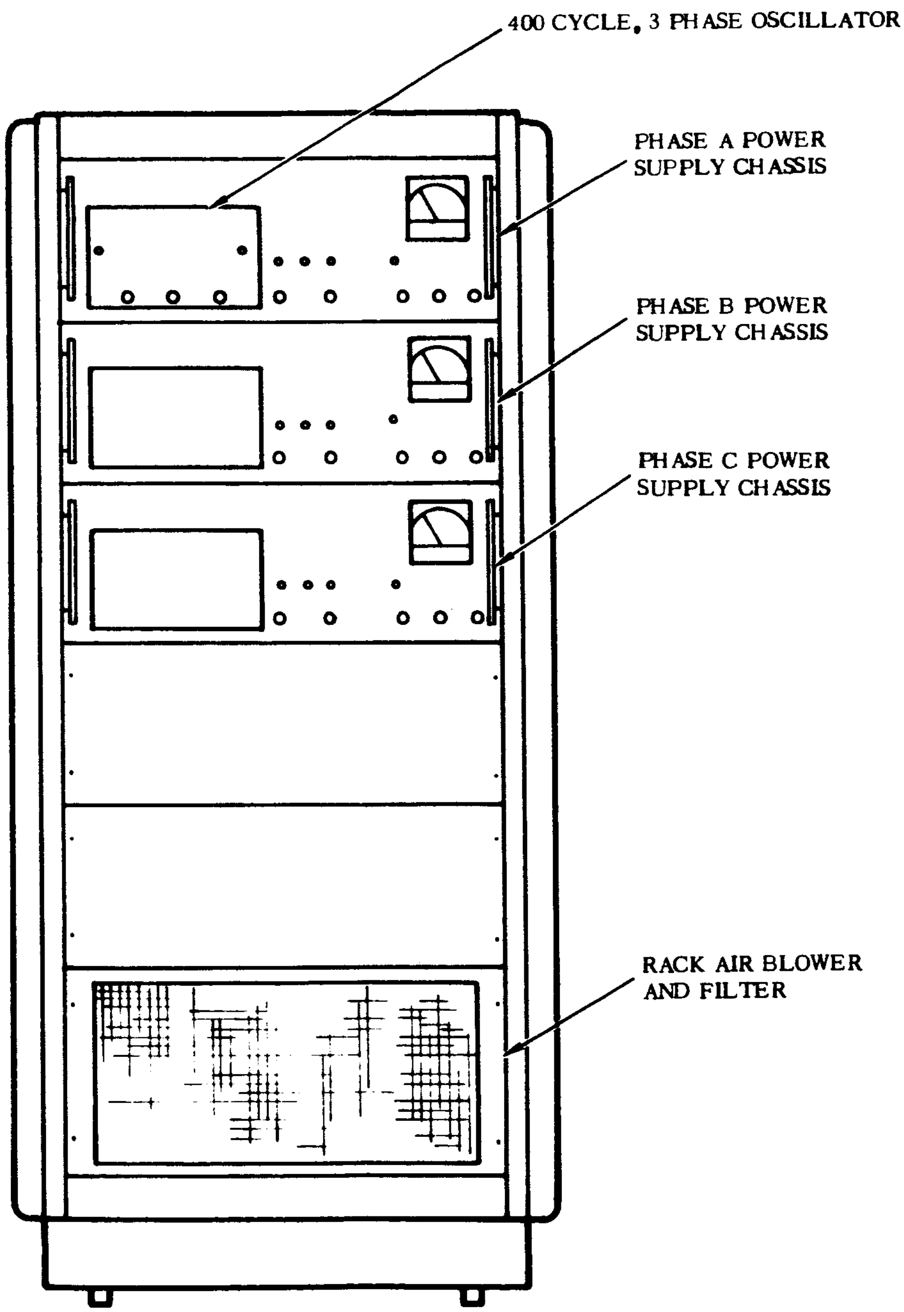


Figure 12.1-17. Front View - Portable 115 Volt 400 Cycle A-C Power Supply

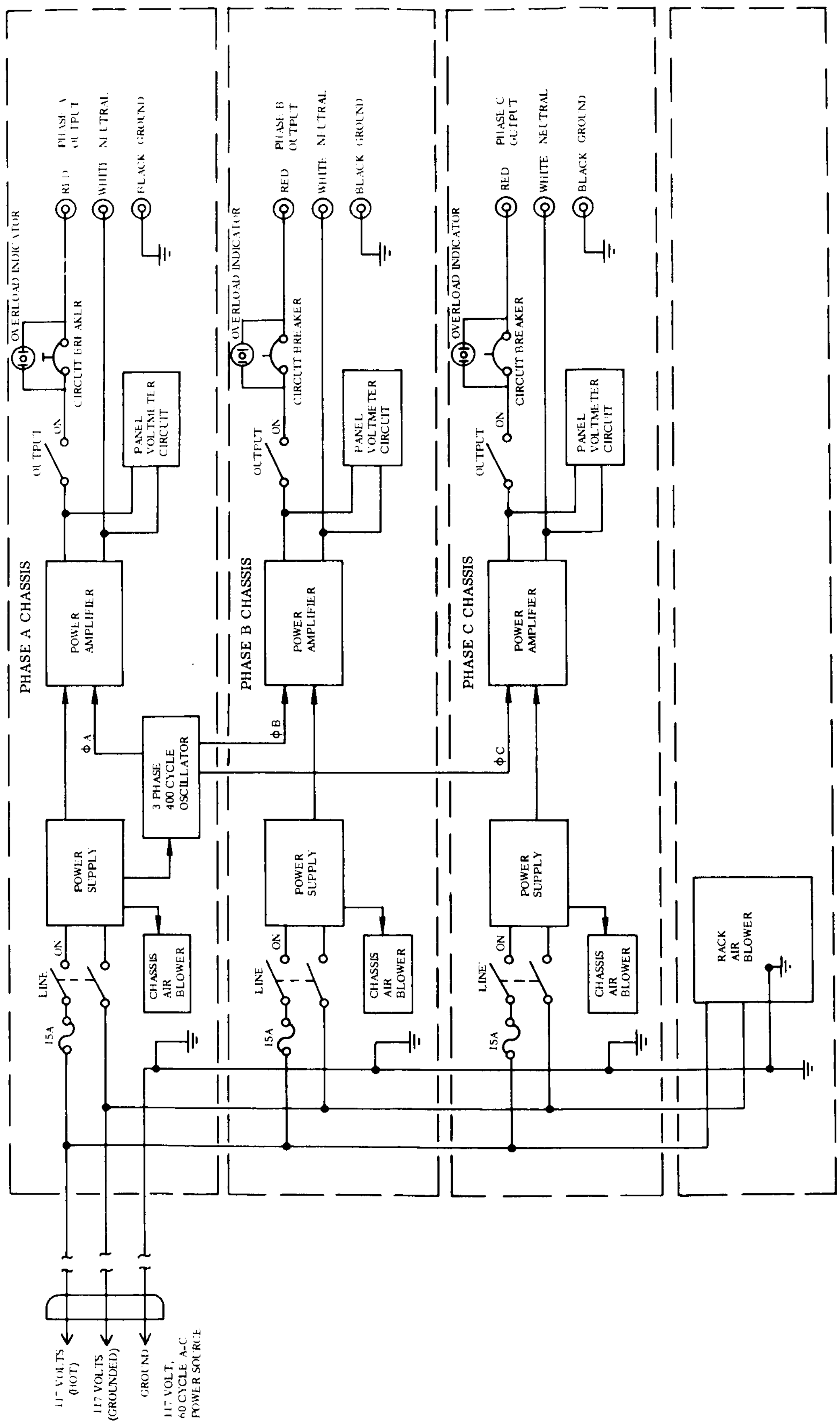


Figure 12. 1-18. Portable 115 Volt, 400 Cycle A-C Power Supply Functional Block Diagram

TABLE 12.1-8. FUNCTIONAL DESCRIPTION OF SWITCHES, CONTROLS AND INDICATORS ON THE POWER SUPPLY AMPLIFIER PANELS

Control or Indicator	Function
Power Input Cable	Connection of the power input cable to a power source will supply power to the rack air blower and to the line switch on each amplifier chassis.
LINE ON Switch	On each chassis, supplies input power to the chassis power supply section and chassis mounted air blower.
LINE ON Indicators	Monitor the presence of input power to the power supply section of each amplifier.
HI VOLTS ON Indicators	Monitor the presence of internal high voltage power within the respective chassis.
Oscillator Unit	Generates a 3 phase, 400 cycle a-c signal, one phase of which is connected each to the power amplifier section of the Phase A, Phase B and Phase C chassis.
OSCILLATOR UNIT OUTPUT VOLTAGE ADJUSTMENT	The output voltage adjustment knob on the oscillator panel controls the signal voltage and is used to set the output voltage of the power supply as indicated by the panel voltmeters.
OUTPUT ON Switch	Controls the power output of each chassis.
OUTPUT ON Indicator	Monitors the presence of a power output from each chassis.
OVERLOAD Indicator	A circuit breaker is provided in each "hot" output lead of each chassis. Operation of this circuit breaker is indicated by the panel OVERLOAD indicator. The circuit breaker may be reset by pressing the RESET button.

Basic amplifier response:	45 to 5000 cps.
Distortion:	0.4%
Voltage stability:	0.1% at fixed line voltage, load, and temperature.
Voltage temperature coefficient:	0.01% per °C.
Regulation vs. line:	±0.5% for ±10% line at full power and 100 to 130 volts output.
Regulation vs. input frequency:	±0.5%
Regulation vs load:	±1.0% maximum, no-load to full load.
Output noise:	60 db below full output.
Output envelope modulation:	At 60 cps input, less than 0.5% of output volts or 60 mv rms, whichever is greater.
Recovery time:	Zero (maximum load transient does not exceed regulation band).

The power supply may be used in several different modes of operation. The output circuit is isolated (floating), therefore, several types of circuit can be set up by appropriate external connections. These are:

a. Single phase, one side grounded

b. Single phase, floating

c. Three phase, wye, neutral floating

d. Three phase, wye, neutral grounded

e. Three phase, wye, one phase grounded

f. Three phase, delta, floating

g. Three phase, delta, one phase grounded

In each case, the output voltage per phase can be adjusted within the normal range, each phase voltage at the same value. The choice of circuit type is the operator's, however, type (a) or (d) are most commonly used. These two types of set up are shown in Figure 12.1-19.

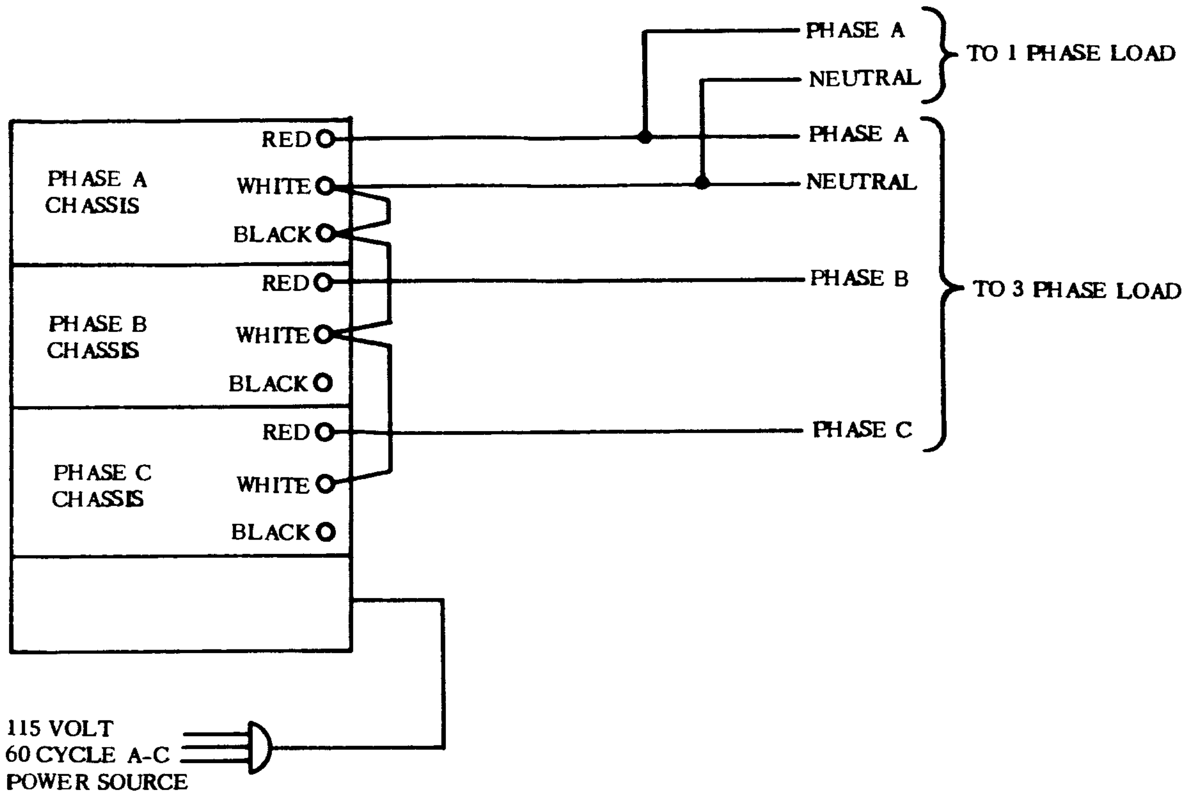


Figure 12.1-19. Output Circuit, 1 Phase and/or 3 Phase Loads, Grounded Neutral Portable 115V, 400 Cycle A-C Power Supply

12.1.6.2.3 Equipment Checkout. Test equipment required for checkout of portable a-c power supply consists of the following:

a. Multimeter, Simpson Model 260 or equivalent. This meter is used to verify that the lead resistance from the grounding contact of the 120 volt, 60 cycle power input plug to the power supply rack does not exceed 0.2 ohm.

b. Load banks, 3 required. These are used to load the output of the power supply unit in a wye connected, ground neutral, 3 phase circuit (see Figure 12-1-20.)

c. Clamp-on ammeter, AC, Weston Model VA-1 or equivalent. With the ammeter applied to each phase lead, each load band is adjusted to draw 3.0 amperes.

d. Voltmeter, AC, Weston Model 433 or equivalent. This voltmeter is used to verify that each line-to-neutral voltage is 115 ± 1 volt and that each line-to-line voltage is 199 ± 1.7 volts. This meter is also used to verify that each line to neutral phase voltage does not change more than 1.2 volts when that phases' load bank is switched on or off.

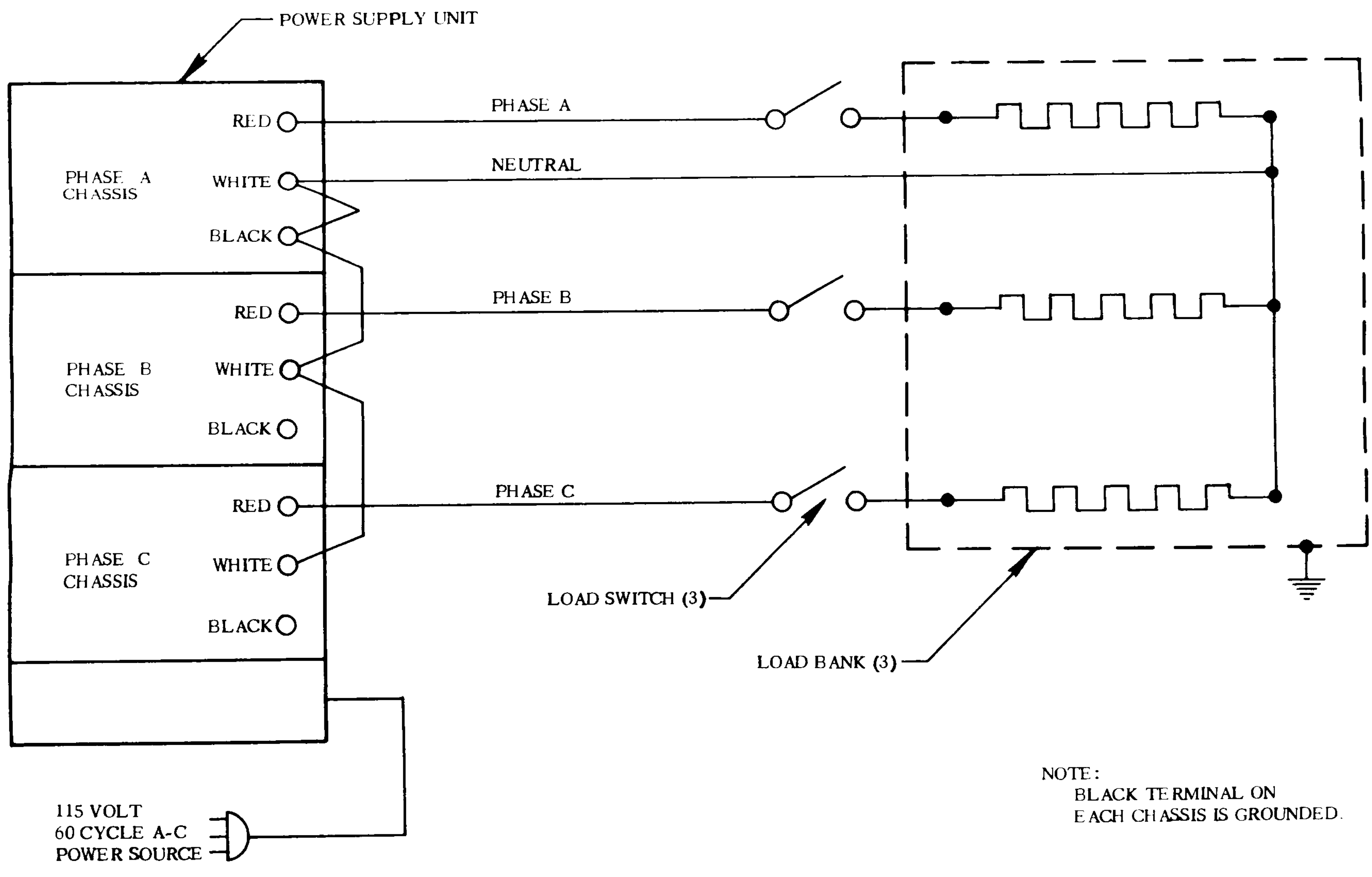


Figure 12.1-20. Load Test Circuit, Grounded Neutral Portable 115V, 400 Cycle, A-C Power Supply

e. Phase sequence indicator, 380 to 420 cps, G.E. Model 44 or equivalent. This indicator is used to verify that the phase sequence of the power supply output is A-B-C.

f. Frequency meter, 400 cps, Aero Model 4059-134 or equivalent. This meter is used to verify that the power supply output frequency is 400 ± 1 cps.

12.1.6.3 Power Supply, Portable DC. Two identical and portable d-c power supplies (P/N 86-21901-011) are available at the launch site. These supplies are used for the test or checkout of ground support equipment which is removed or isolated from a parent system. These supplies are also used to energize selected circuits when power is not available from the permanently installed GSE power supply equipment. These units may also be used for charging batteries.

The d-c power supply consists of a single unit 19-1/2 inches wide by 14-5/8 inches high by 14-1/2 inches deep and weighing 105 pounds. Carrying handles are provided on each end of the unit and the unit is designed for bench top use. The front panel contains the following components:

a. Line power switch

b. D-C output voltmeter

c. D-C output ammeter

d. D-C voltage adjustment control knob

e. D-C voltage adjustment high-low range switch

f. D-C output current limit adjustment control knob

g. D-C output terminals.

The unit is convection cooled. No air fan or blower is provided. Figure 12.1-21 shows a front view of one of the power supply units.

12.1.6.3.1 Functional Description. The d-c power supply unit converts 120 volt, 60 cycle, single phase a-c power input to d-c output power, adjustable from 1 to 36 volts dc. Input power is furnished from a facility 120 vdc, 60 cycle power source. Output d-c power is taken from the unit at the power output terminals on the front panel of the unit.

The power supply uses a transformer/silicon controlled rectifier circuit to provide widerange adjustable output voltage, close voltage regulation, low load-voltage response time, adjustable output current limiting, and temperature stability.

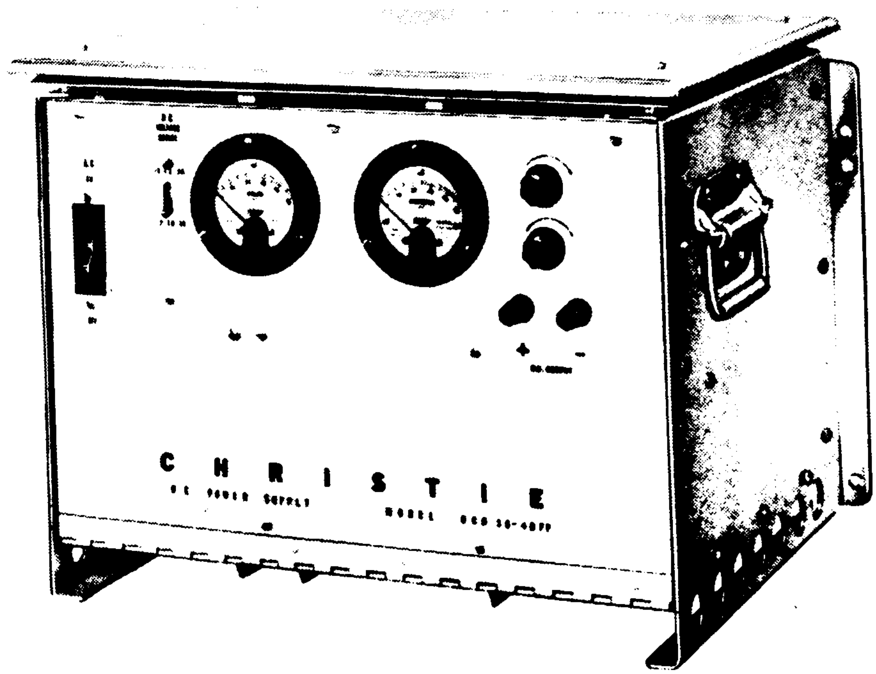


Figure 12.1-21. Portable D-C Power Supply

Connections are provided for remote sensing voltage regulation. The output circuit is completely isolated so that the unit may be operated with the output floating or with either terminal grounded. Two or more units may be operated in series or parallel for higher voltage or load requirements. On-Off control and overload protection are provided by a switch type magnetic circuit breaker mounted on the front panel.

12.1.6.3.2 Characteristics and Capability. The d-c portable power supply unit has the following characteristics and capability:

Input power	115 volts ±10%, at 57 to 63 cps, single phase ac.
Output voltage:	1 to 36 volts dc, continuously adjustable.
Output current:	0-40 amperes dc continuous.
Output power:	1500 watts, maximum.
Voltage regulation:	Static - ±0.5% or ±0.14 volt whichever is greater for any combination of load current or line voltage within rated limits.

	Dynamic - ±3 to 5 volts for no-load to full load or vice versa, ±10% a-c input voltage step change, or at a-c input "turn on" or "turn off."
Voltage ripple:	1% or 0.1 volt RMS, whichever is greater.
Response time:	For 63% reduction in transients, down to 20% of maximum rated output voltage, no-load to full load response time is 25 to 50 milliseconds; full load to no-load is 100 milliseconds.

Once the unit has been checked out and the voltage and current flow adjusted to meet system demands, the power output of the unit may then be switched off and on by means of the power supply power input switch.

Charging lead-acid or nickle-cadmium batteries is accomplished by setting the power supply voltage to the desired end voltage and the current limit control to the desired maximum charging rate. The power supply will automatically charge and "float" the battery when it is fully charged. The power supply can be used to charge silver-zinc batteries at a selected maximum charging rate but will not provide automatic charge limiting for this type battery.

12.1.6.3.3 Equipment Checkout. Test equipment required for checkout of the portable d-c power supply consists of the following:

a. Multimeter, Simpson Model 260 or equivalent. This meter is used to verify that the lead resistance from the grounding contact of the 120 volt, 60 cycle power input plug to the power supply unit case does not exceed 0.2 ohm.

b. Load bank, with required ranges of 0.15 to 3.0 ohms, 1500 watts continuous by adjustment or adjustable in 10% steps, approximately. This load bank, together with an ammeter and voltmeter, are connected to the output terminals of the load bank as shown in Figure 12.1-22.

c. Voltmeter, dc, 0-50 volt range, Weston Series 931 or equivalent. See Figure 12.1-22 for application.

d. Ammeter, dc, 0-50 ampere range, Weston Series 931 or equivalent.

With the load bank and meters connected to the power unit as shown in Figure 12.1-22, checks of the power supply rated output and of voltage control over various ranges of load current are made to verify that the power supply is operating satisfactorily.

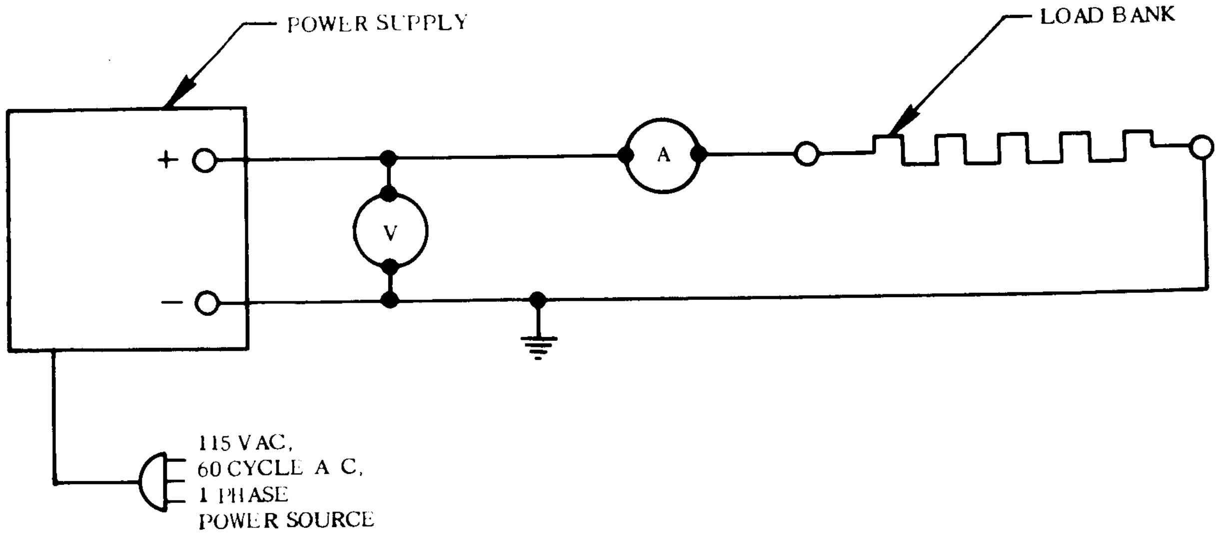


Figure 12.1-22. Portable D-C Power Supply Test Circuit

12.2 ELECTRICAL CONTROL SYSTEMS

All control systems and instrumentation required for direct controls during vehicle launch are located in the blockhouse. A means of monitoring and control of these systems during integrated launch control operations (countdown sequence) is provided by the Test Conductor System. Associated with the monitoring function of the Test Conductor System is a government furnished Blockhouse Monitor System. A checkout of this integrated launch control system is provided by a Launch Control Simulator.

12.2.1 TEST CONDUCTOR SYSTEM FUNCTION AND CONTROL. The Test Conductor System is used to summarize all the prerequisite conditions for a safe launch of the vehicle and generate a vehicle release signal at the proper time.

The Test Conductor System provides for monitoring and control of the launch countdown sequence by means of a display and control panel. A Ready Summary display indicates the ready status of the various systems required to be activated prior to initiation of start sequence. A Release Summary display shows prime launch sequence events that occur after initiation of the start sequence. Unsatisfactory completion of any event in this launch sequence (launch ladder) will result in a failure of the system to generate a release signal. A malfunction in the launch ladder after the start sequence has been initiated will result in an automatic cutoff of the booster engine. A Cutoff display indicates the particular function which initiated the engine cutoff, if cutoff should occur. A manual control for stopping the engine firing sequence is provided on the Cutoff control panel. For reference, GD/C Drawing 55-98006 is an elementary schematic of the Test Conductor System.

12.2.1.1 Test Conductor System Component. The Test Conductor System equipment consists of a console located in the blockhouse. The relays and relay logic necessary for the operation of the system are located in the lower portion of the console. Figure 12.2-1 shows the Test Conductor System display and control panel. The function of each indicator and control on the panel is described in Table 12.2-1.

A block diagram of the Test Conductor System is shown in Figure 12.2-2. Chassis No. 1, No. 2 and No. 3 contain the relays and relay logic associated with the Ready Summary, Release Summary and Cutoff lamp matrices, respectively. The interface signals between the elements shown in the block diagram are described in Table 12.2-2.

12.2.1.2 Test Conductor System Checkout. The initial checkout of the Test Conductor System validates the system. This checkout verifies the indicated command and response signals are correct in the system and to the interfacing points of associated systems. This checkout also verifies the Ready Summary logic, launch ladder sequence (Release Summary) and cutoff circuitry.

Other checkouts and tests of the Test Conductor System are performed during prelaunch operations. These tests, in general, do the following:

a. Demonstrate the launch prestart sequence using simulated ready signals provided by the Launch Control Simulator in the blockhouse (and test relays in the engine ground box).

b. Demonstrate the release sequence using simulated ready signals provided by the Launch Control Simulator (and test relays in the engine ground box).

c. Demonstrate the Test Conductor launch control cutoff capability for ground power failure and by sequential removal of each of the individual functions from the release ladder.

d. Demonstrate the capability of the sequencer to hold at three specified hold-fire points.

e. Demonstrate a release sequence including umbilical ejection using actual and simulated signals.

f. Demonstrate automatic termination of the liquid helium chilldown system.

g. Demonstrate automatic Centaur fuel vent valve close command during engine sequence.

The checkout tests are supported by the Launch Control Simulator (see Paragraph 12.2.3) and the Gantry Test Rack (see Paragraph 6.4, Volume I of this report).

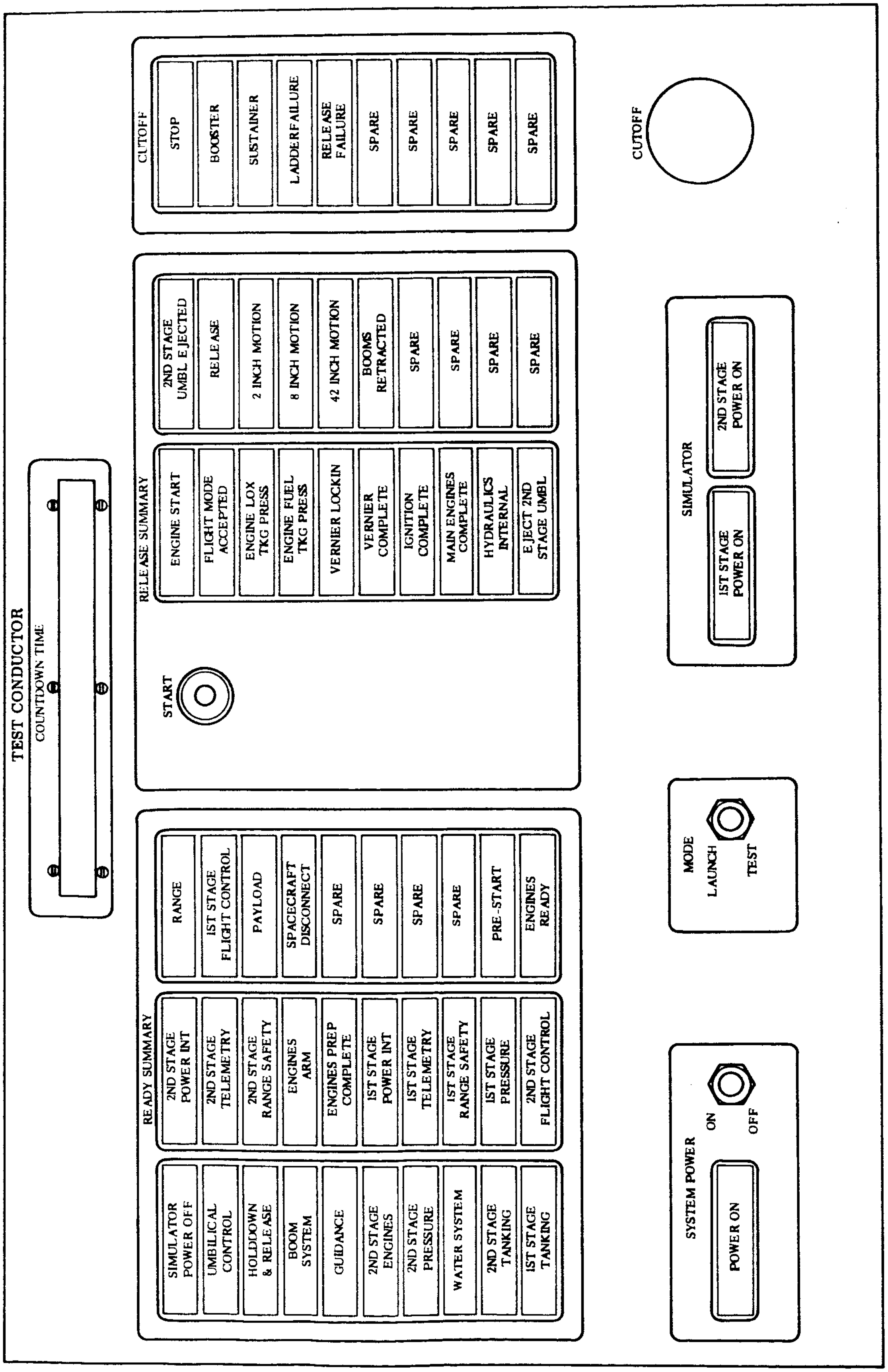


Figure 12.2-1. Test Conductor Control Panel

TABLE 12.2-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON THE TEST CONDUCTOR PANEL

Control or Indicator	Function
SYSTEM POWER Switch	Turns the TEST CONDUCTOR SYSTEM power on. The POWER ON Indicator lights green when the switch is turned on.
MODE Switch	In the LAUNCH position, supplies 28 vdc to the "prestart" and "release" ladders as well as to the cutoff circuitry in the Test Conductor System.
SIMULATOR POWER OFF Indicator	Lights green when the power is off to the booster stage and second stage simulators. The Test Conductor needs this indication so as to know that no "ready" signals in the launch ladder are being simulated during a launch.
UMBILICAL CONTROL Indicator	Is illuminated green by a normally open set of contacts of the Umbilical Control Ready Relay and indicates two things. a. The umbilicals are connected to the vehicle. b. The Eject Ready Relay in the launcher accessories system is energized, i.e., the circuitry is ready to eject the umbilicals when the command is given. This relay also has a normally open set of contacts in the "prestart" ladder.
HOLDDOWN AND RELEASE Indicator	A normally open set of contacts of the Holddown and Release Ready Relay illuminates this green light when they close. When this relay is energized it indicates that the Holddown Slave Cylinders are charged to 6250 psi. The "prestart" ladder also contains a normally open set of contacts of this relay.

TABLE 12.2-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON THE TEST CONDUCTOR PANEL (Continued)

Control or Indicator	Function
BOOM SYSTEM Indicator	Indicator is illuminated green by the closing of a normally open set of contacts of the Boom System Ready Relay. This light gives the indication that the Umbilical Boom Hydraulic System is charged to a pressure of 625 psi. This hydraulic system is used to raise the upper and lower boom when the signal is received. A normally open set of contacts of this relay is in the "prestart" ladder.
GUIDANCE Indicator	Illuminates green when the Guidance Ready Signal has been received from the missile guidance checkout equipment. It is illuminated by the Guidance Ready Relay. The relay also has normally open contacts in the "prestart" ladder.
2ND STAGE ENGINES Indicator	Illuminates green when the preflight checks of the second stage engines are complete and the engines are in a ready-to-launch condition. It is illuminated by the Second Stage Engine Ready Relay. A normally open set of contacts of this relay is in the "prestart" ladder.
2ND STAGE PRESSURE Indicator	Illuminated green by the closing of a normally open set of contacts of the Second Stage Pressure Ready Relay. This relay gives the Test Conductor the indication that the second stage pressurization system is in ready condition and the ready switch on the second stage pressurization console has been thrown to the ready position. This relay is also in the "prestart" ladder.
WATER SYSTEM Indicator	Indicator is illuminated green by the Water System Ready Relay. Green indication informs Test Conductor that the valves are open on the water system and the deluge is armed. This relay is also in the "prestart" ladder.

TABLE 12. 2-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON THE TEST CONDUCTOR PANEL (Continued)

Control or Indicator	Function
2ND STAGE TANKING Indicator	Illuminated green by the closing of a normally open set of contacts of the Second Stage Tanking Relay when the relay becomes energized. This light gives the Test Conductor the following information: a. The liquid hydrogen is transferred to the second stage vehicle b. The liquid hydrogen fill and drain valve is closed c. The liquid oxygen fill and drain valve is closed. A normally open set of contacts of this relay is in the "prestart" ladder.
1ST STAGE TANKING Indicator	Illuminated green by the closing of a normally open set of contacts of the First Stage Tanking Ready Relay, indicates three things: a. The airborne fill and drain valves for both the liquid oxygen and RP1 are closed b. The sustainer and booster pre-valves for the RP1 are open c. The slug sequence has been started. This relay also has a set of normally open contacts in the "prestart" ladder.
2ND STAGE POWER INT Indicator	Illuminates green when the second stage vehicle has been transferred to internal power. It is illuminated by the Second Stage Power Internal Ready Relay. The relay also has a set of normally open contacts in the "prestart" ladder.
2ND STAGE TELEMETRY Indicator	Illuminated green by the closing of a set of normally open contacts of the Second Stage Telemetry Ready Relay. When this "ready" signal is received the following three things have been completed:

TABLE 12.2-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON THE TEST CONDUCTOR PANEL (Continued)

Control or Indicator	Function
	a. The telemetry system has been turned on b. The "C" Band Tracking systems are on c. The commutators are on. A normally open set of contacts of this relay is in the "prestart" ladder.
2ND STAGE RANGE SAFETY Indicator	Illuminated green by the closing of a set of normally open contacts of the Second Stage Ready Relay when the relay becomes energized. The following functions must be completed to send this ready signal: a. Both command channels No. 1 and No. 2 are on internal power b. The destruct package is electrically and mechanically armed. The "prestart" ladder contains a normally open set of contacts of this relay.
ENGINES ARM Indicator	Illuminates green when the operator on the Engine Control Panel throws the Arm switch on. This switch energizes the Arm Buss in the Engine Control System. It is from this buss that all the start functions of the First Stage engines receive +28 volts dc.
ENGINES PREP COMPLETE Indicator	Indicates that the engine preparation complete ladder has been completed. This ladder contains the functions necessary for a safe start of the first stage engines.
1ST STAGE POWER INT Indicator	Illuminated green by the closing of a normally open set of contacts of the First Stage Power Internal Relay. This "ready" signal is received when the booster has been transferred to internal power. The "prestart" ladder also contains a normally open set of contacts of this relay.

TABLE 12.2-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON THE TEST CONDUCTOR PANEL (Continued)

Control or Indicator	Function
1ST STAGE TELEMETRY Light	When green gives the Test Conductor the indication that all the booster telemetry systems are in the ready condition. It is illuminated by the First Stage Telemetry Ready Relay, which also has a set of normally open contacts in the "prestart" ladder.
1ST STAGE RANGE SAFETY Light	It is illuminated green by the First Stage Range Safety Ready Relay and indicates two things: a. The destruct package has been installed on the booster b. The destruct package is armed. A normally open set of contacts of this relay is in the "prestart" ladder.
1ST STAGE PRESSURE Light	When green, gives the indication that the booster is on internal pressure. It is illuminated by the First Stage Pressure Ready Relay, which also has a set of normally open contacts in the "prestart" ladder.
2ND STAGE FLIGHT CONTROL Indicator	Illuminated green by the closing of a normally open set of contacts of the Second Stage Flight Control Ready Relay. When this relay becomes energized it indicates three things: a. The operator of the autopilot console has thrown the autopilot ready switch to the ready position. b. The flight programer is armed c. The flight programer is zeroed. This "ready" signal is also in the "prestart" ladder.

TABLE 12.2-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON THE TEST CONDUCTOR PANEL (Continued)

Control or Indicator	Function
RANGE Indicator	When illuminated, it indicates that the range is clear for launching and that the missile tracking stations are ready. It is illuminated by the Range Ready Relay. The "prestart" ladder also contains a normally open set of contacts of this relay.
1ST STAGE FLIGHT CONTROL Indicator	Illuminated green by the closing of a set of normally open contacts of the First Stage Flight Control Ready Relay. When the "ready" signal is received it indicates: a. Gyros are nulled b. Engines are nulled (zero position) c. Flight programer is set at zero time d. Flight programer is armed (ready for operation at 2 in. rise) e. Gyro spin is O.K. f. The five heaters are in tolerance. Another set of normally open contacts of this relay is located in the "prestart" ladder.
PAYLOAD Indicator	This "ready" signal is received when the payload (aboard the Centaur stage) is in a flight readiness condition. The green PAYLOAD LIGHT is illuminated by the Payload Ready Relay. This relay also has contacts in the "prestart " ladder.
SPACECRAFT DISCONNECT Indicator	This green light is illuminated by the Spacecraft Disconnect Ready Relay. This relay is energized as long as the umbilical plug to the spacecraft is mated. A normally open set of contacts of this relay is in the "prestart" ladder.

TABLE 12.2-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON THE TEST CONDUCTOR PANEL (Continued)

Control or Indicator	Function
PRESTART Indicator	Is illuminated green by the Prestart Complete Relay. When all indicators in the Ready Summary are illuminated, the Prestart Ladder is complete. When this happens, the Prestart Complete Relay is energized, it in turn illuminates the Prestart Indicator and along with Engine Prep Complete Relay (Engine control system) energize a Missile Prep Complete Relay.
ENGINES READY Indicator	Illuminated green by the closing of normally open contacts of Missile Prep Complete and Engine Prep Complete Relays. The energizing of these two relays enables the START Pushbutton and completes the Ready Summary.
START Pushbutton	Initiates the start sequence of the engines and is activated after the PRESTART COMPLETE and ENGINES READY Indicators are illuminated.
ENGINE START Indicator	Indicates that the engine start sequence has been initiated. It is illuminated when the START Switch has been activated.
FLIGHT MODE ACCEPTED Indicator	Illuminated green by the closing of a set of normally open contacts of the Flight Mode Accept Relay. This relay is energized when a flight accept signal is received from the Guidance Ground Control System indicating inertial.
ENGINE LOX TKG PRESS Indicator	Indicates that the Booster Engine LO_2 Start Tank, located on the outside of the Main LO_2 Tank, has been pressurized to 600 psi.

TABLE 12.2-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON THE TEST CONDUCTOR PANEL (Continued)

Control or Indicator	Function
ENGINE FUEL TKG PRESS Indicator	Illuminâtes when the booster engine fuel start tank, located inside the main fuel tank, has been pressurized to 600 psi.
VERNIER LOCKIN Indicator	Illuminated green by the closing of a normally open set of contacts of the Vernier Lockin Relay. This relay given an indication that the vernier propellant valve is open. This relay also enables the cutoff circuitry in the Test Conductor System.
VERNIER COMPLETE Indicator	Is illuminated green by a signal directly from the Engine Control System. This signal gives the Test Conductor the indication that the vernier engines are up to speed and the chamber pressure is O. K.
IGNITION COMPLETE Indicator	The engine ignition has been completed in the proper sequence when this light is illuminated by a signal from the Engine Control System.
MAIN ENGINES COMPLETE Indicator	When green, gives an indication that the sustainer and booster fuel manifold pressure is O. K. for 96% thrust.
HYDRAULIC INTERNAL Indicator	Is illuminated green by the Internal Hydraulics Ready Relay. This ready signal signifies three things: a. Hydraulic pressure in the booster is 3000 psi b. Return pressure is 30 psi c. Oil has been evacuated. This relay also has a set of normally open contacts in the release ladder.

TABLE 12.2-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON THE TEST CONDUCTOR PANEL (Continued)

Control or Indicator	Function
EJECT 2ND STAGE UMBL Indicator	When green, gives the Test Conductor an indication that the signal has been sent to eject the second stage umbilicals. It is illuminated by a normally open set of contacts of the Eject Second Stage Umbilicals Relay. This relay also has contacts in the release ladder.
2ND STAGE UMBL EJECTED Indicator	Is illuminated green by the Second Stage Umbilicals Ejected Relay. This relay becomes de-energized when the second stage umbilicals and the aft umbilical plate are ejected. A normally closed set of contacts of the relay is in the release ladder.
RELEASE Indicator	When green, gives the Test Conductor an indication that the signal has been sent to the release solenoid. It is illuminated by a normally open set of contacts of the Release Relay.
2 INCH MOTION Indicator	Is illuminated green by a signal from the launcher accessories system, when the vehicle has activated the two inch rise microswitch on the launcher.
8 INCH MOTION Indicator	Is illuminated green by a signal from the launcher accessories system when the vehicle has activated the 8 inch rise microswitch in the launcher.
42 INCH MOTION Indicator	Is illuminated green by the de-energizing of the Eject Ready Relay in the Launcher Accessories System. This relay drops out when the 42 inch umbilical plug comes out, i.e., at 42 inch vehicle motion.

TABLE 12.2-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON THE TEST CONDUCTOR PANEL (Continued)

Control or Indicator	Function
BOOMS RETRACTED Indicator	Is illuminated green by a signal from the launcher accessories system when the umbilical booms are in the full retracted position and completes the Release Summary.
1ST STAGE POWER ON Indicator (SIMULATOR)	Is illuminated amber from the 1st stage simulator when the simulator system power is on. This light should be off in a normal countdown so the Test Conductor will know that no 1st Stage Ready Signals can be simulated.
2ND STAGE POWER ON Indicator (SIMULATOR)	Is illuminated amber from the 2nd stage simulator when the simulator system power is on. This light should be off in the normal countdown so the Test Conductor will know that no 2nd Stage Ready Signals can be simulated.
STOP Indicator	Is illuminated red by a signal from the Engine Control System. This signal can be initiated from any one of six cutoff circuits. These circuits are: a. Cutoff signal sent from the CUTOFF Switch on the Test Conductor Panel b. Cutoff signal sent from the STOP Switch on the Engine Control Panel c. A ladder fault cutoff signal sent from the Test Conductor System d. A release failure cutoff signal sent from the Test Conductor System e. Cutoff signal sent from the Sustainer Over-speed Tachometer f. Pressurization re-stepped from internal.
BOOSTER Indicator	Is illuminated red from one of the four cutoff circuits.

TABLE 12.2-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON THE TEST CONDUCTOR PANEL (Continued)

Control or Indicator	Function
	These four circuits are: a. The BOOSTER CUTOFF Button on the Engine Control Panel b. The SUSTAINER CUTOFF Button on the Engine Control Panel c. Cutoff signal sent from the Sustainer Overspeed Tachometer d. Pressurization re-stepped from internal.
SUSTAINER Indicator	Is illuminated if a cutoff signal is generated from the SUSTAINER CUTOFF Button, the SUSTAINER OVER-SPEED Tachometer, or if pressurization has re-stepped from internal.
LADDER FAILURE Indicator	Is illuminated red 5.25 seconds after Vernier Engine Lockin ladder has failed. A cutoff signal is also sent to the engine control system at the same time.
CUTOFF Switch	This switch is pushed by the Test Conductor when he wants to send a complete cutoff to the engine control system.
COUNTDOWN TIME Indicator	Gives the Test Conductor a digital readout of the countdown time from T-90 minutes to T + 10 minutes.

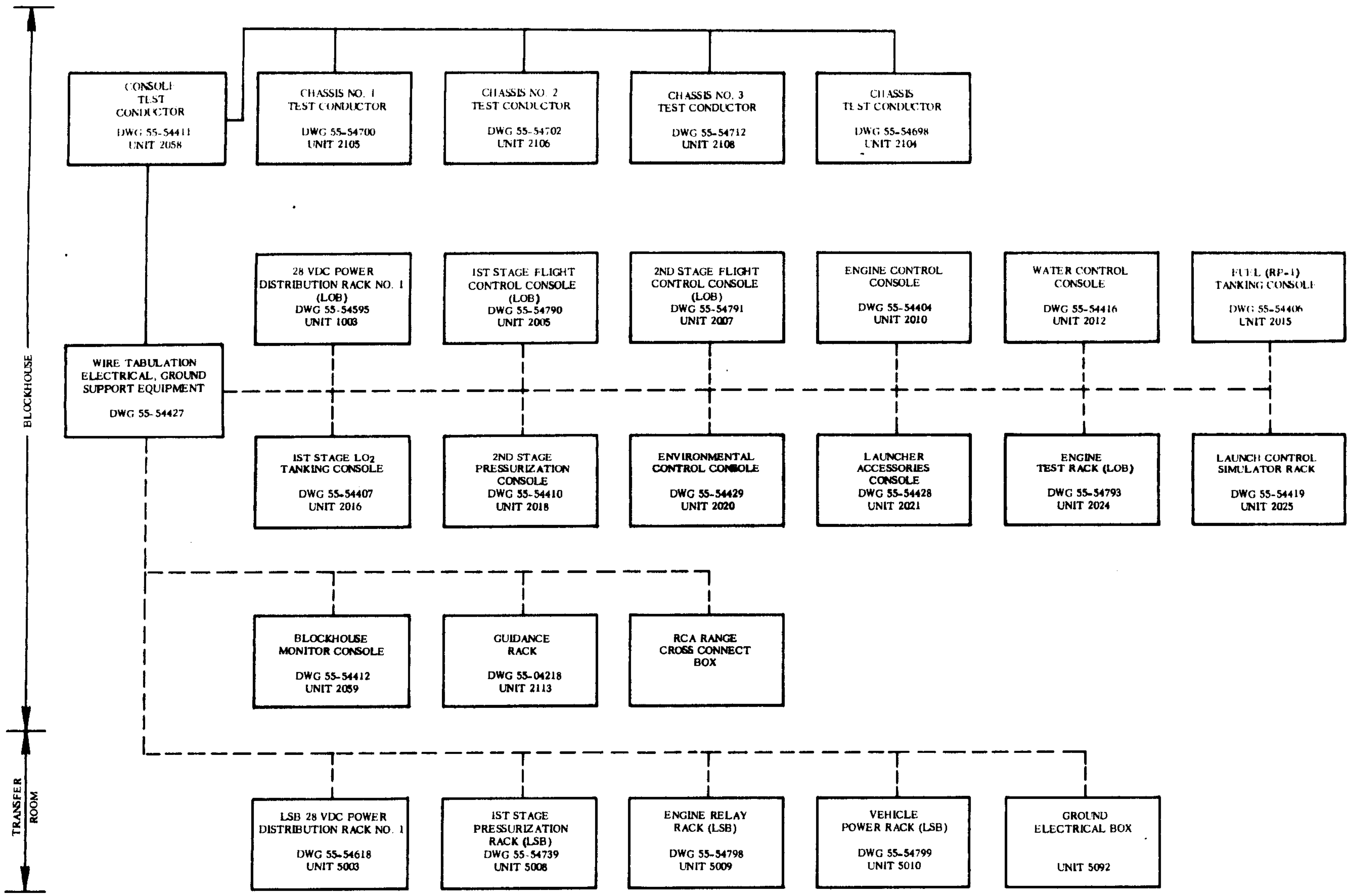


Figure 12.2-2. Test Conductor System Block Diagram

TABLE 12. 2-2. TEST CONDUCTOR INTERFACE SIGNALS

Signal	Source
UMBILICAL CONTROL READY	This ready signal can be received from either the Launcher Accessories System or the 1st Stage Control Simulator.
HOLDDOWN AND RELEASE READY	This ready signal can be received either from the Launcher Accessories System or the 1st Stage Launch Control Simulator.
BOOM SYSTEM READY	This signal is received from the Launcher Accessories System.
2ND STAGE ENGINE READY	This ready signal is received from either the Engine Control System or the 2nd Stage Simulator System.
2ND STAGE PRESSURE READY	This ready signal is received from either the 2nd Stage Pressurization System or the 2nd Stage Launch Control Simulator.
2ND STAGE POWER INTERNAL	This ready signal can be received from either the Vehicle Power System or the 2nd Stage Launch Control Simulator.
2ND STAGE TELEMETERING READY	This signal is received from the RF System.
2ND STAGE RANGE SAFETY READY	This ready signal is received from either the 2nd Stage Range Safety or the 2nd Stage Launch Control Simulator System.
GUIDANCE READY	This ready is received from the Guidance Ground Control System or from the 2nd Stage Stage Launch Control Simulator System.
WATER SYSTEM READY	This signal comes from the Water System or from the 1st Stage Launch Control Simulator.
1ST AND 2ND STAGE TANKING READY	Both of these ready signals come from the Propellant Tanking System.

TABLE 12.2-2. TEST CONDUCTOR INTERFACE SIGNALS (Continued)

Single	Source
1ST STAGE POWER INTERNAL	This ready signal is received from the Vehicle Power System or from the 1st Stage Launch Control Simulator.
1ST STAGE RANGE SAFETY READY	This signal is received from the RF System.
1ST STAGE RANGE SAFETY READY	This ready signal is received from either the Range Safety System or from the 1ST STAGE Launch Control Simulator.
1ST STAGE PNEUMATICS INTERNAL	This signal is received from the 1st Stage Pressurization Control System or from the 1st Stage Launch Control Simulator.
2ND STAGE FLIGHT CONTROL READY	This ready signal is received from the 2nd Stage Flight Control System or from the 2nd Stage Launch Control Simulator.
RANGE SAFETY	This signal is sent to the Test Conductor System from the Range Interconnect Box or from the 1st Stage Launch Control Simulator.
1ST STAGE FLIGHT CONTROL READY	This ready signal is received from the 1st Stage Flight Control System or from the 1st Stage Launch Control Simulator.
PAYLOAD READY	This ready signal is received from the Payload System or from the 2nd Stage Launch Control Simulator.
SPACECRAFT DISCONNECT READY	This ready signal is received from a loop through the spacecraft umbilical or from the 2nd Stage Launch Control Simulator.
POWER	All system power for the Test Conductor System is received from the d-c and 400 Cycle Power Distribution System.

TABLE 12.2-2. TEST CONDUCTOR INTERFACE SIGNALS (Continued)

Signal	Source
1ST STAGE SIMULATOR	The following signals are received from the 1st Stage Launch Control Simulator System: a. Simulator Power On b. Simulation of 2 Inch Motion c. Simulation of Main Engine Complete.
2ND STAGE SIMULATOR	The following signals are received from the 2nd Stage Launch Control Simulator System: a. Simulator Power On b. Simulation of Eject 2nd Stage Umbilicals c. Simulation of Flight Mode Accepted.
LAUNCHER ACCESSORIES - OUTPUTS	The following signals are sent to the Launcher Accessories System: a. Eject 2nd Stage Umbilical b. Vehicle Release Signal.
LAUNCHER ACCESSORIES - INPUTS	The following signals are received from the Launcher Accessories System: a. Booms Retracted b. 2 Inch Motion c. 8 Inch Motion d. 42 Inch Motion.
OUTPUTS TO ENGINE SYSTEM	The following signals are sent to the Engine Control System: a. Prerelease Cutoff Disarm b. Prestart Complete c. Engine Start d. Engine Cutoff from Cutoff Button e. Engine Cutoff from Cutoff Circuitry.
INPUTS FROM ENGINE SYSTEM	The following signals are received from the Engine Control System: a. Vernier Engine Lock-In b. NAA Engine Cutoff c. Engines Arm

TABLE 12.2-2. TEST CONDUCTOR INTERFACE SIGNALS (Continued)

Signal	Source
	d. Engine Preparation Complete e. Engine Ready f. Engine Fuel Tank Pressurized g. Engine LO_2 Tank Pressurized h. Ignition Complete i. Main Engine Complete j. Booster Cutoff k. Sustainer Cutoff l. Stop Light
LOCKOUT SIGNALS	The Pressurization System receives a 1st Stage and 2nd Stage Pressurization Lockout Signal from the Test Conductor System.
GUIDANCE INPUT	The Flight Mode Accepted signal is received from the Guidance Ground Control System.
HYDRAULICS INPUT	The Hydraulic Control System sends the Internal Hydraulic Relay to the Test Conductor System.

12.2.2 BLOCKHOUSE MONITOR SYSTEM FUNCTION AND CONTROL. The Blockhouse Monitor System is associated with the Test Conductor System. This system is Government furnished and interfaces with the Test Conductor System. This monitor provides control of the range sequences, camera starts, visual display of hold time, display of available hold time and display of plus time after 2 inch motion. For reference, GD/C Dwg. 55-98008 is an elementary schematic of this system.

12.2.2.1 Blockhouse Monitor System Components. A block diagram of the Blockhouse Monitor System is shown in Figure 12.2-3. The control panel for this system is shown in Figure 12.2-4. A function description of the displays on the control panel is given in Table 12.2-3.

12.2.2.2 Blockhouse Monitor System Checkout. This system is used in conjunction with the Test Conductor System and checkout is performed at the same time as, and in a similar manner to, the Test Conductor System (see Paragraph 12.2.1.2).

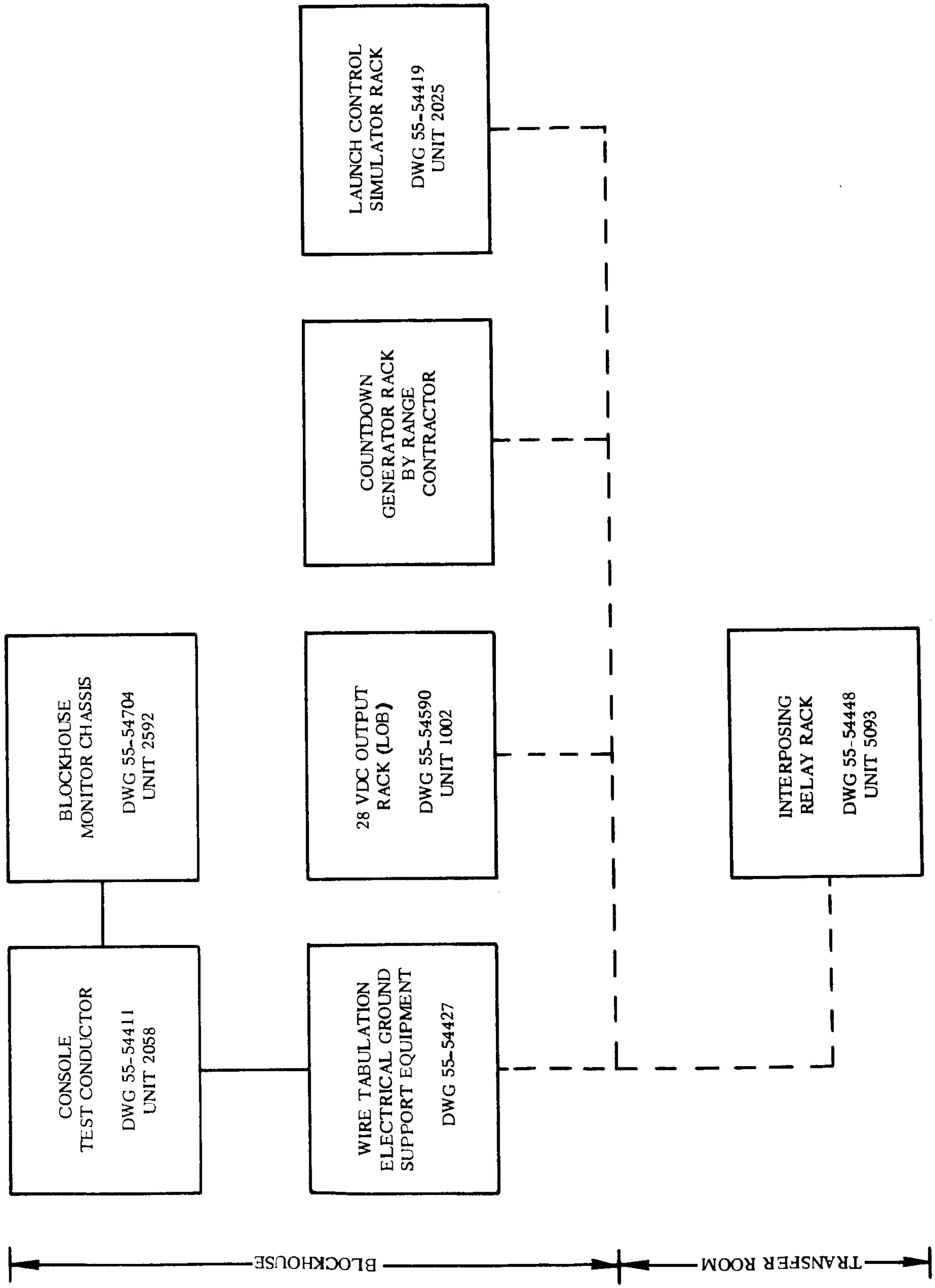


Figure 12.2-3. Blockhouse Monitor Block Diagram

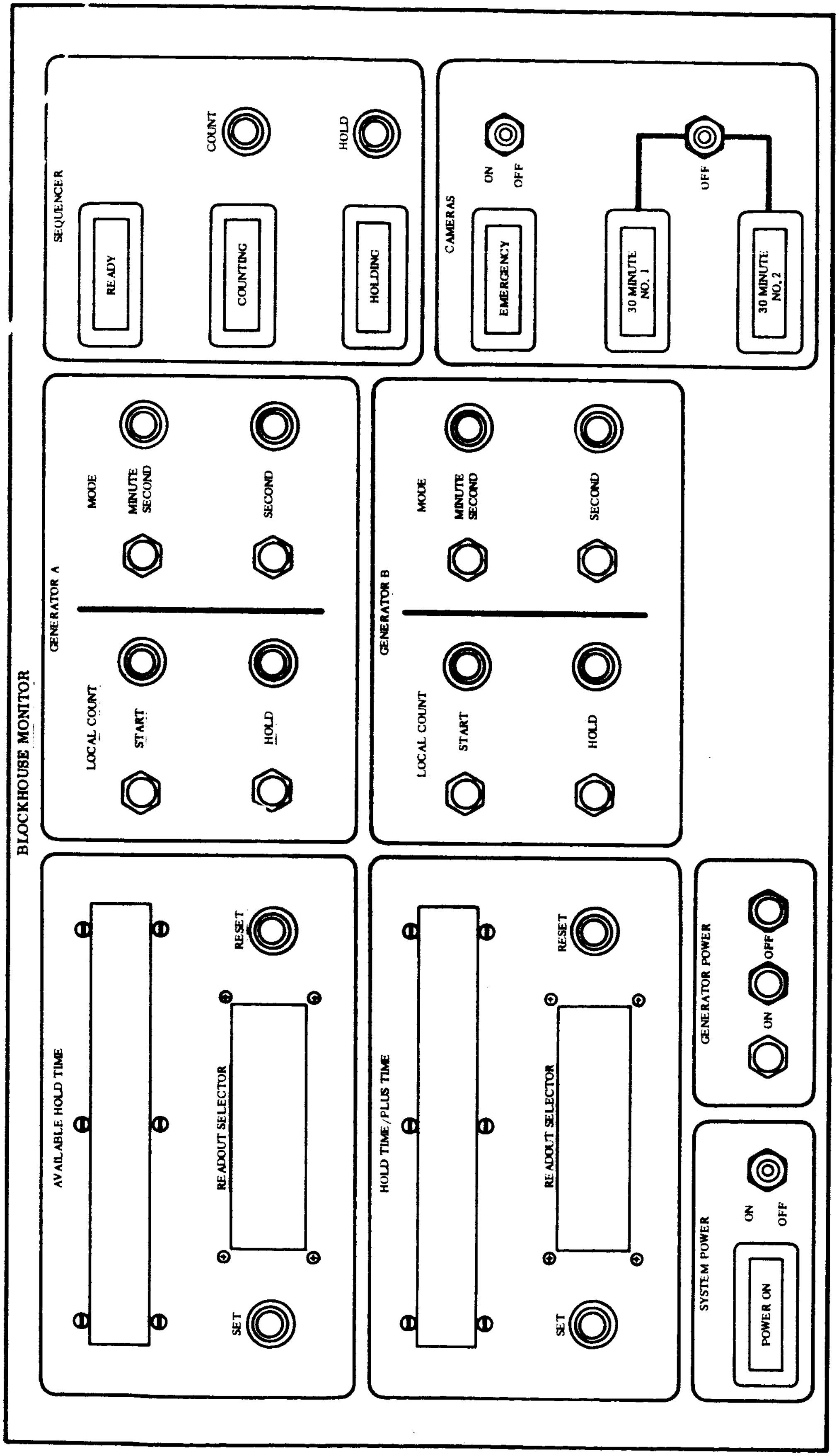


Figure 12.2-4. Blockhouse Monitor Control Panel

TABLE 12.2-3. FUNCTIONAL DESCRIPTION OF CONTROLS AND INDICATORS ON BLOCKHOUSE MONITOR PANEL

Control or Indicator	Function
SYSTEM POWER Switch	Turns the Blockhouse Monitor power on. Power is also supplied to the Pad Safety Officer relay chassis and range contractors countdown generator, patch rack and switching unit. SYSTEM POWER indicator illuminates when power is on.
GENERATOR POWER Switches	The ON switch, when depressed, turns on the range contractor's countdown generator power supply. The GENERATOR POWER indicator illuminates when the generator's power supply is operating. The OFF switch, when depressed, turns off the range contractor's countdown generator's power supply and extinguishes the indicator.
SEQUENCER READY Indicator	Illuminates when sequencer start power from the range interface is available; indicates the sequencer is ready to start counting.
SEQUENCER COUNT Switch	When momentarily depressed, will initiate Sequencer start. When the sequencer starts, the SEQUENCER COUNTING indicator will be illuminated.
SEQUENCER HOLD Switch	When momentarily depressed, will stop the sequencer count. The SEQUENCER HOLDING indicator is illuminated when the HOLD switch is depressed.
CAMERAS Switches	The emergency cameras may be turned on by placing the upper switch under the camera section to ON. The EMERGENCY indicator is illuminated when the emergency camera switch is on.

TABLE 12.2-3. FUNCTIONAL DESCRIPTION OF CONTROLS AND INDICATORS ON BLOCKHOUSE MONITOR PANEL (Continued)

Control or Indicator	Function
	The lower switch selects the appropriate 30 minute camera to be turned on. The corresponding indicator is illuminated, when the switch is thrown to the desired camera position.
AVAILABLE HOLD TIME Indicator	The AVAILABLE HOLD TIME indicator displays the available hold time if a given launch window is to be met. This indicator can either be driven from Generator A or Generator B, normally during launch from Generator A. The RESET button, when depressed, resets the digital AVAILABLE HOLD TIME indicator to zero. The readout selector is a digiswitch, which is used to select the available hold time. Each digit is selected by a dial on the digiswitch. The digiswitch code is set into the indicator by a SET switch.
HOLD TIME/PLUS TIME Indicator	The HOLD TIME/PLUS TIME Indicator displays the hold time in minutes and seconds and the plus time after two inch motion in seconds. This indicator can either be driven from Generator B or A normally during launch from Generator B. The RESET button, when depressed, resets the digital HOLD TIME/PLUS TIME Indicator to zero. Each digit is selected by a dial on the digiswitch. The digiswitch code is set into the indicator by a SET switch.
GENERATOR A START & HOLD Controls	The START and HOLD switches when depressed, send the appropriate start or hold signal to the countdown generator A. The START light indicates, when illuminated, that the countdown Generator A is started. The HOLD light when illuminated indicates the countdown Generator A is in a hold condition.

TABLE 12.2-3. FUNCTIONAL DESCRIPTION OF CONTROLS AND INDICATORS ON BLOCKHOUSE MONITOR PANEL (Continued)

Control or Indicator	Function
GENERATOR A MODE Controls	The MINUTE SECOND MODE switch when depressed, sends a minute-second command to countdown Generator A causing it to count in a minute and second fashion. The MINUTE SECOND light, when illuminated, indicates that the generator is in the minute-second mode. The SECOND MODE switch, when depressed, sends a second command to the countdown Generator A, causing it to count in a second fashion. The SECOND MODE light, when illuminated indicates that the generator is in a second mode.
GENERATOR B START, HOLD & MODE Controls	The start, hold, mode controls for Generator B are identical to Generator A except the commands and indicators refer to Generator B.

12.2.3 LAUNCH CONTROL SIMULATOR FUNCTION AND CONTROL. A Launch Control Simulator is provided to simulate various Centaur vehicle system functions. These simulated functions are used to checkout and test associated equipment during preparations for launch. The simulator equipment, when combined with similar equipment for the booster vehicle, provides the capability to simulate the complete prestart ladder in the Test Conductor console (see Paragraph 12.2.1). Also, the release ladder in the Test Conductors console can be simulated except for the booster engine cutoff contacts. The simulator has the additional capability of initiating certain simulated commands such as "eject umbilicals". For reference, GD/C Dwg. 55-98037 is an elementary schematic of the Simulator Second Stage.

12.2.3.1 Launch Control Simulator Component. The simulator equipment consists of a control panel, relay logic and associated cable assemblies.

Figure 12.2-5 shows the Launch Control Simulator Console, including first and second stage simulator panels. The remainder of the system description in this section is limited to the simulator for the second stage Centaur vehicle except where reference to the first stage is required for clarity.

A functional description of switches and indicators on the Simulator Second Stage panel is presented in Table 12.2-4.

A listing of the Simulator Second Stage interfaces is given in Table 12.2-5.

A block diagram of the simulator system is shown in Figure 12.2-6.

12.2.3.2 Launch Control Simulator Checkout. The initial checkout of the Launch Control Simulator validates the system. The simulator system is exercised to demonstrate the indicated commands and responses that exist in the system and commands to the interfacing points of associated systems.

The simulator system is used in checking out the launch control systems such as the Test Conductor and Blockhouse Monitor Systems and, in so doing, perform a "self-test" functional checkout of its own system.

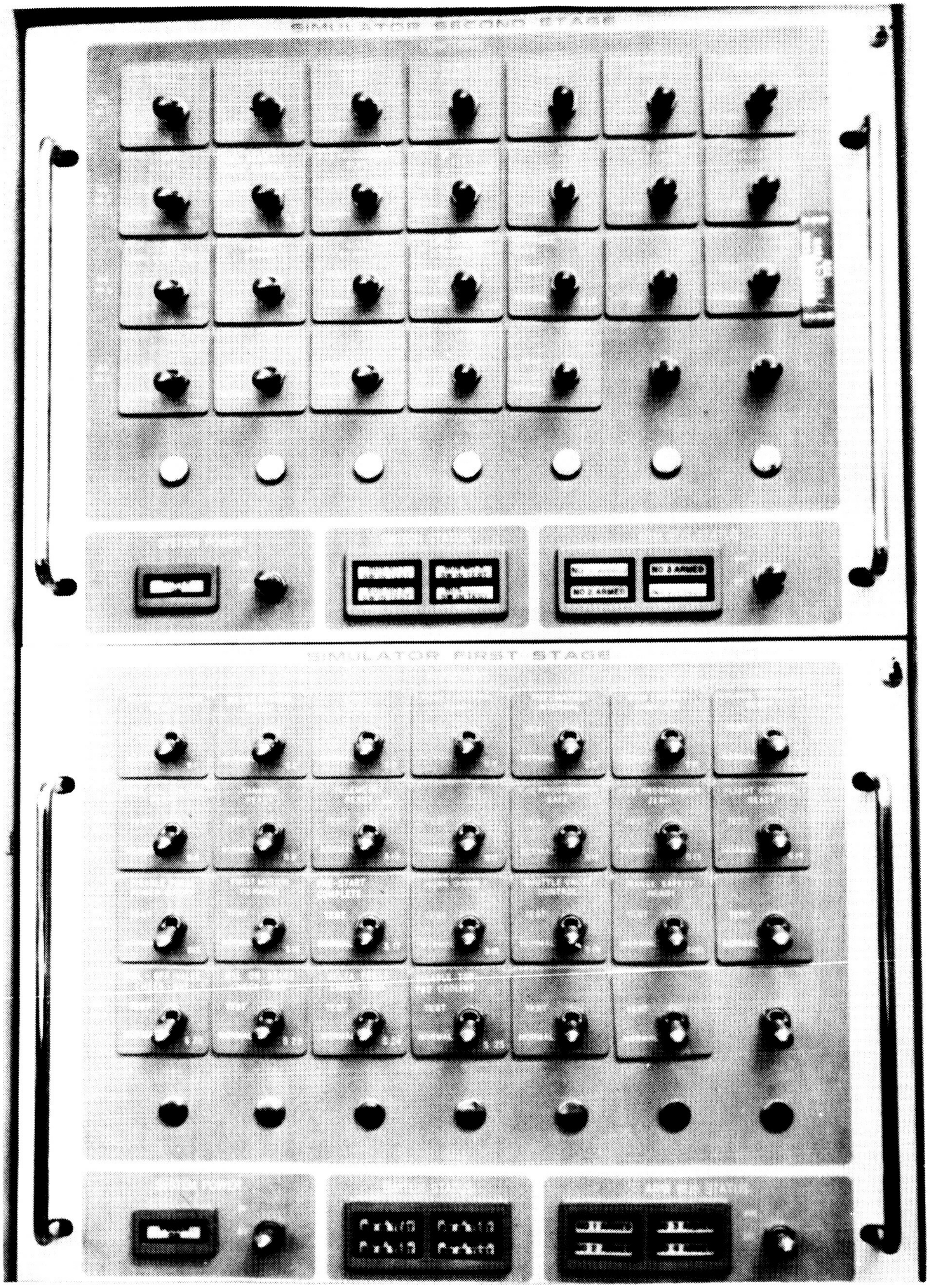


Figure 12.2-5. Launch Control Simulator Console

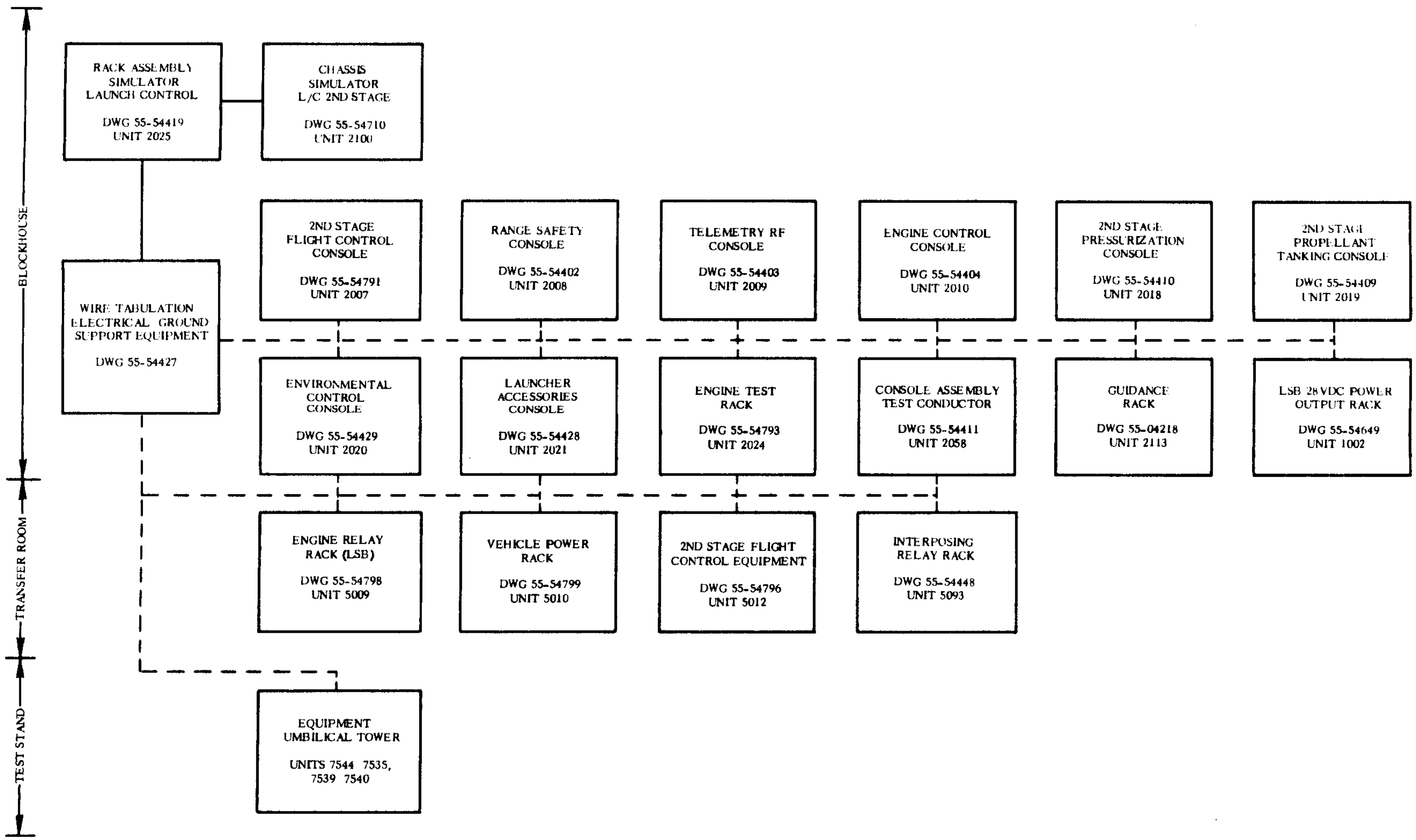


Figure 12.2-6. Block Diagram, Simulator Second Stage

TABLE 12.2-4. FUNCTIONAL DESCRIPTION OF CONTROLS AND INDICATORS ON SECOND STAGE SIMULATOR PANEL

Control or Indicator	Function
SYSTEM POWER Switch	Turns the second stage L/C Simulator power on. SYSTEM POWER indicator illuminates when power is on.
ARM BUS Switch	Arms the second stage L/C simulator buses No. 1, 2, 3 and 4 simultaneously. The ARMED indicator illuminates as each particular bus is armed.
SWITCH STATUS Indicators	Indicate when a simulator switch is in the test position. Indicator "BUS NO. 1 SW IN TEST" is illuminated when any switch S1 thru S7 is in test. Indicator "BUS NO. 2 SW IN TEST" is illuminated when any switch S8 thru S14 is in test. Indicator "BUS NO. 3 SW IN TEST" is illuminated when any switch in the 3rd horizontal row is in test. Indicator "BUS NO. 4 SW IN TEST" is illuminated when any switch in the 4th horizontal row is in test.
Simulation of T/C Prestart Ready Functions	The first function of the 2nd Stage Simulator to be discussed will be its capability to simulate ready signals on the T/C prestart ladder. Both first and second stages of the simulator are utilized to completely simulate the prestart ladder.
Simulation Switches Used in Prestart Simulation	On the Second Stage Simulator, eleven switches are used to simulate ready functions on the Test Conductor prestart ladder. Eight of these switches, in test position, simulate a ready signal by energizing the appropriate T/C relay. Following is a list of these switches and originating system of the ready signals which are simulated:

TABLE 12.2-4. FUNCTIONAL DESCRIPTION OF CONTROLS AND INDICATIORS ON SECOND STAGE SIMULATOR PANEL (Continued)

Control or Indicator	Function
Switch	Simulates Ready Signal From:
S3 GUIDANCE READY	Guidance Ground Control
S4 ENGINES READY	Engine System
S5 PRESSURE READY	2nd Stage Pressure System
S6 POWER INTERNAL	Vehicle Power System
S22 RANGE SAFETY READY	2nd Stage Range Safety System
S7 FLIGHT CONTROL READY	2nd Stage F/C System
S11 PAYLOAD READY	Payload System
S18 SPACECRAFT DISCONNECT	
BOOM SYSTEM READY Switch (S1)	Simulates a boom system ready signal to the T/C. In test position, this switch energizes two relays (A5K1 & A1K1) in the second stage simulator, closing their normally open contacts. This energizes the Lower Pneumatic Pressure OK, Lower Accumulator Pressure OK, Lower Accumulator Level OK, Hydraulic Return Valve Open (Lower), Upper Pneumatic Pressure OK, Upper Accumulator Pressure OK, Upper Accumulator Level OK, and Hydraulic Return Valve Open (Upper) Relays in the Launcher Accessory System. This completes the necessary requirements for a boom system ready signal to be sent to the T/C.

TABLE 12.2-4. FUNCTIONAL DESCRIPTION OF CONTROLS AND INDICATIONS ON SECOND STAGE SIMULATOR PANEL (Continued)

Control or Indicator	Function
TANKING READY Switch (S2)	Simulates a second stage tanking ready signal to the test conductor in test position. This switch energizes (A2K1) Tanking Ready Relay in the simulator, closing three normally open contacts and opening one normally closed contact. This energizes the LO_2 Fill and Drain Valve Closed, LH_2 Fill and Drain Valve Closed, and LH_2 Transferred Relays in the propellant tanking system. This fulfills the requirements for a 2nd stage tanking ready signal to be sent to the T/C, the normally closed set of contacts in test position are opened to disable a lockup signal to be sent to the LH_2 transferred Relay during test.
TELEMETRY READY Switch (S8)	Simulates a 2nd stage telemetry ready signal to the T/C. In test position, this switch energizes the Telemetry Ready Relay (A6K12) in the RF system; when energized this relay allows a 2nd stage telemetry ready signal to be sent to the T/C.
T/C Prestart Ladder Complete Simulation	With the switches S1, S2, and S8 above, plus (S1) Holddown & Release Ready, (S2) Water System Ready, (S3) Range Ready, (S4) Power Internal Ready, (S5) Pneumatics Internal, (S8) Umbilical Control Ready, (S9) Tanking Ready, (S10) Telemetry Ready, (S14) Flight Control Ready, and (S20) Range Safety Ready on the First Stage Simulator Panel in test, the complete T/C prestart ladder can be simulated. The First Stage Simulator switches mentioned are explained in detail in the first stage L/C Simulator System description, GD/C Drawing No. 55-01321.

TABLE 12.2-4. FUNCTIONAL DESCRIPTION OF CONTROLS AND INDICATIONS ON SECOND STAGE SIMULATOR PANEL (Continued)

Control or Indicator	Function
T/C Release Ladder Simulation	With all the ready functions on the T/C prestart ladder simulated, the prestart complete contacts on the T/C release ladder close. Both 1st and 2nd stage simulator switches are required to completely simulate the release ladder. Three switches on the second stage panel are utilized to accomplish this task.
FLIGHT MODE ACCEPTED Switch (S12)	In Test position, simulates a flight mode accepted signal from Guidance Ground Control System by energizing the flight mode accepted relay in the T/C.
UMBILICALS EJECTED Switch (S14)	In test position, energizes the Umbilicals Ejected Relay (A2K3) in the second stage simulator, causing its normally closed contacts to open; when opened, the 2nd Stage Umbilicals Ejected Relay in the T/C is de-energized simulating a second stage umbilicals ejected signal sent from the launcher accessories system.
T/C Release Ladder Complete Simulation	With switches S12 and S14 above, plus (S6) Main Engines Complete, and (S7) Internal Hydraulics Ready on the First Stage Simulator Panel in test position, the complete T/C release ladder can be simulated and a release signal sent. The first stage switches are described in detail in the First Stage L/C Simulator System description, GD/C Drawing No. 55-01321.
F/C PROGRAMMER ZERO Switch (S10)	In Test position, simulates a F/C programmer zero signal from the Centaur programmer by energizing the F/C Programmer Zero Relay in the F/C system.

TABLE 12.2-4. FUNCTIONAL DESCRIPTION OF CONTROLS AND INDICATIONS ON SECOND STAGE SIMULATOR PANEL (Continued)

Control or Indicator	Function
COMMAND SIMULATOR Switches	Certain switches do not simulate a ready signal but actually initiate a certain command. These switches are described below.
EJECT UMBILICALS Switch (S13)	In test position, energizes the Eject 2nd Stage Umbilicals Relay sending an umbilical eject signal to the launcher accessories system. This switch cannot eject the second stage umbilicals unless all other necessary logic in the launcher accessories system is completed.
DISABLE UMBILICALS EJECT Switch (S15)	In test position, energizes the Disable Umbilicals Eject Relay (A2K4) in the 2nd stage simulator, opening two normally closed contacts. These contacts, when open, will not allow an umbilicals eject signal to be sent to the Electrical Eject Upper Umbilical Relay and the Upper Umbilical and Aft Plate Lanyard Firing Time Delay Drop Out Relay in the launcher accessories system, thereby not permitting the umbilicals to be ejected.
RETRACT BOOMS Switch (S16)	In test position, has the ability to generate a retract booms signal to the launcher accessories system, causing the booms to retract. This switch cannot generate a retract booms signal unless the 2nd stage umbilicals have been ejected.
FUEL VENT VALVE CLOSED Switch (S9)	In test position, gives a LH_2 vent valve closed indication to the vernier igniter firing circuit and disables the command to open the vent door (which is generated from this circuit).

TABLE 12.2-4. FUNCTIONAL DESCRIPTION OF CONTROLS AND INDICATIONS ON SECOND STAGE SIMULATOR PANEL (Continued)

Control or Indicator	Function
HORN DISABLE Switch (S17)	In the test position, generates a signal to the second stage pressurization system to de-energize the emergency warning horn.

TABLE 12.2-5. SIMULATOR SECOND STAGE INTERFACES

Signal	Description
Simulated Signals: a. Guidance Ready b. Engines Ready c. Pressure Ready d. Power Internal Ready e. Flight Control Ready f. Payload Ready g. Flight Mode Accepted h. Range Safety Ready i. Spacecraft Disconnect	Sent to Test Conductor System
BOOM SYSTEM READY	Simulated Lower Pneumatic Press OK, Low Accumulator Press OK, Lower Accumulator Level OK, Hyd. Return Valve Open, Upper Pneumatic Press. OK; Upper Accumulator Press. OK, Upper Accumulator Level OK, & Hyd. Return Valve Open signals are sent to the launcher accessories system.
TANKING READY	Simulated LO_2 Fill & Drain Valve Closed, LH_2 Fill & Drain Valve Closed, and LH_2 Transferred signals are sent to the propellant tanking system.
TELEMETRY READY	A Simulated Ready signal is sent to the RF system.
F/C PROGRAMMER ZERO	A Simulated F/C Programmer Zero signal is sent to the F/C system.
EJECT UMBILICALS	An eject umbilicals command signal is sent to the T/C system.
RETRACT BOOMS	A Retract Booms command signal is sent to the launcher accessories system.
FUEL VENT VALVE CLOSED	A Simulated LH_2 Vent Valve Close signal is sent to the Second Stage Pressurization Control System. This signal also interfaces with the second stage purge system to give a disable of the open door command.

TABLE 12.2-5. SIMULATOR SECOND STAGE INTERFACES (Continued)

Signal	Description
HORN DISABLE	A signal is sent to the second stage pressurization control system to disable the emergency horn.

12.3 BONDING AND GROUNDING

12.3.1 BONDING AND GROUNDING, VEHICLE SYSTEMS. The vehicle electrical power system uses a combination multipoint and single-point grounding philosophy. The vehicle skin acts as the ground plane for all equipment mounted on the vehicle.

All electrical and electronic equipment mounted in the forward section of the vehicle has the ground return lead connected to studs on the main power changeover switch. These studs act as the forward ground plate and are connected to the vehicle skin.

An additional ground plate is located in the aft section and in the adapter section of the vehicle and are used to ground electrical equipment situated in these areas. All ground studs on the vehicle are interconnected by wire. The booster grounding system is tied to the Centaur vehicle ground system through the staging disconnect.

For ground operations, the vehicle is grounded to the GSE systems through the Centaur power umbilical. A grounding plan diagram is shown in Figure 12.3-1.

Electrical and electronic package housings or canisters are connected to the vehicle structure ground plane by direct metal to metal junction except in the case of shock mounted units, which use bonding jumpers across the shock mounts, and the static inverter and autopilot pulse rebalance unit. These two components have the neutral tied into their cases and the cases are tied, in turn, to the vehicle skin. Shields or interconnecting harnesses, where applicable, are tied electrically to the back shell of the plug connector and grounded through the receptacle connector to the package housing.

12.3.2 BONDING AND GROUNDING, LAUNCH COMPLEX. The equipment ground, static ground, utility and ground support equipment power supply systems grounds are all tied to a grounding counterpoise. This counterpoise system consists of a number of 1 inch × 40 foot copperweld ground rods interconnected by No. 4/0 AWG copper wire.

Tied into the grounding counterpoise are all structural steel, air conditioning ducts, cable trays, control equipment enclosures, conduit, plumbing and any metallic body enclosing or located near an electrical circuit which is accessible to personnel. The Centaur vehicle grounding system is also tied to this grounding counterpoise as well as the negative bus of the 28 vdc power and the 7 vdc power together with the neutrals of the 60 cycle and 400 cycle a-c power systems.

Figure 12.3-2 is a simplified schematic of the launch site shielding, grounding, and bonding method.

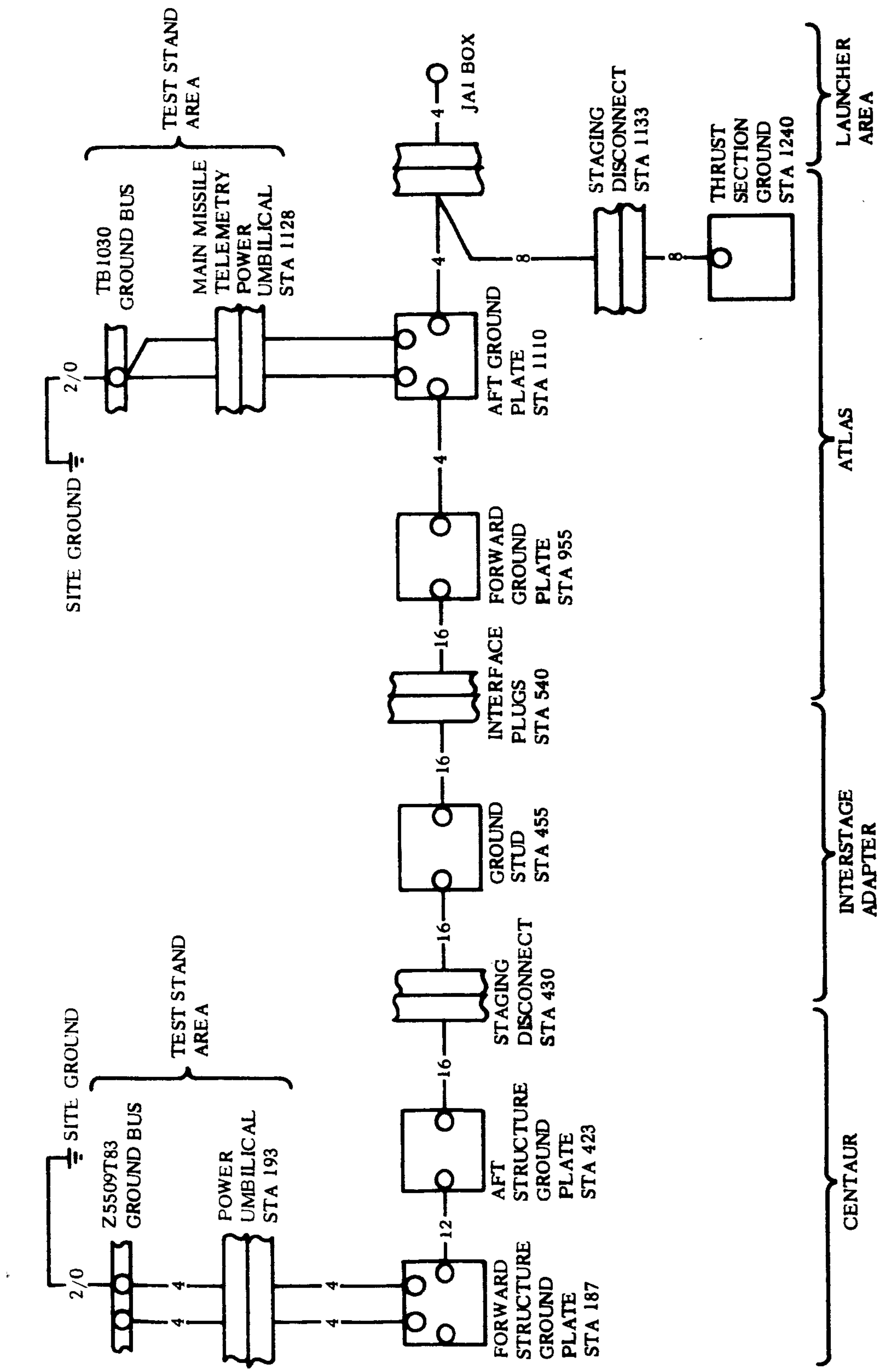


Figure 12.3-1. Vehicle Ground Diagram

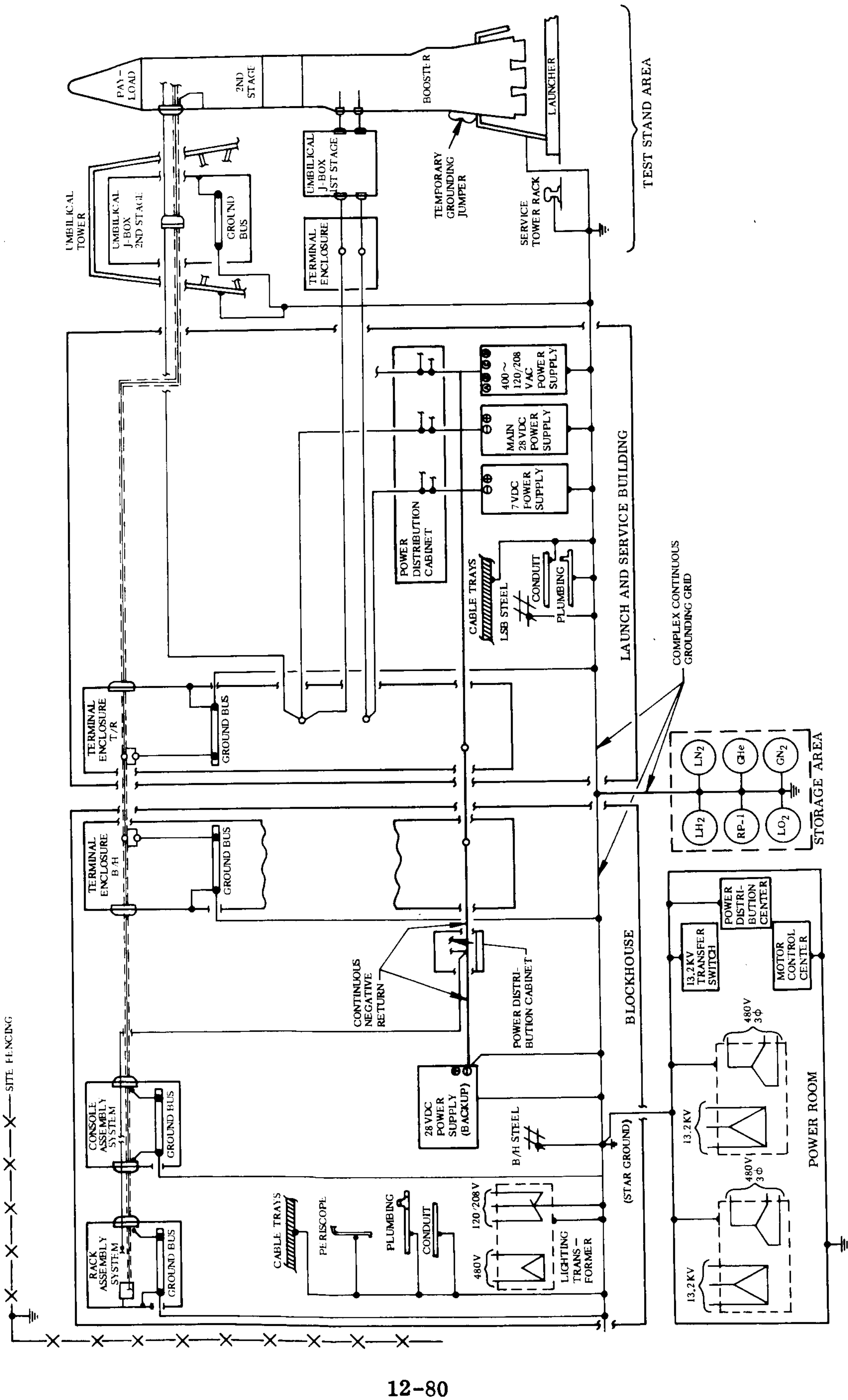


Figure 12.3-2. Simplified Schematic - Shielding, Grounding, and Bonding Method

SECTION XIII

FLIGHT CONTROL SYSTEM

13.1 SYSTEM FUNCTION AND CONTROL

The Centaur Flight Control System consists of two major subsystems; the vehicle flight control (autopilot), and the flight control ground support equipment, see Figure 13.1-1.

13.1.1 CENTAUR VEHICLE FLIGHT CONTROL SUBSYSTEM FUNCTION. The Centaur vehicle flight control (autopilot) subsystem provides the primary control functions required for vehicle stabilization during powered flight and attitude orientation during coast phase of flight. In addition, the flight control system provides switching sequences required for programmed flight. Figure 13.1-2 identifies the vehicle co-ordinate system and the Centaur vehicle engine locations.

The vehicle flight control subsystem consists of two electromechanical timers and one each auxiliary electronics, gyro and servoamplifier units. Signal flow between units of the flight control subsystem, and between the flight control subsystem and other systems or subsystems, is shown in Figure 13.1-3. Each unit provides telemetry outputs and accepts GSE control inputs.

The electromechanical timers each contain a timing motor, gear trains, and cam-driven switches which control electronic switches in the accessory unit, which, in turn, control functions of the flight control subsystem, as well as other vehicle systems.

The gyro unit routes vehicle coordinate steering signals received from the guidance system to the proper vehicle co-ordinate control channel, limits their amplitude to acceptable equivalent vehicle rate levels, and applies proper damping to the signals per vehicle rate information as sensed by pitch, yaw, and roll rate gyros contained within the unit.

The servoamplifier unit conditions and amplifies the control signals to the servo-valves on the hydraulic actuators of the vehicle main engines. Transducers mounted on the actuators sense the engine displacement and feed proportional signals to summing networks on the servoamplifier inputs to complete position servo loops. Pitch, yaw, and roll integrators in the servoamplifier compensate for steady-state errors, such as engine thrust misalignment or unbalance.

The servoamplifier unit contains the threshold and logic circuitry associated with the selective firing of the hydrogen peroxide engines during unpowered flight.

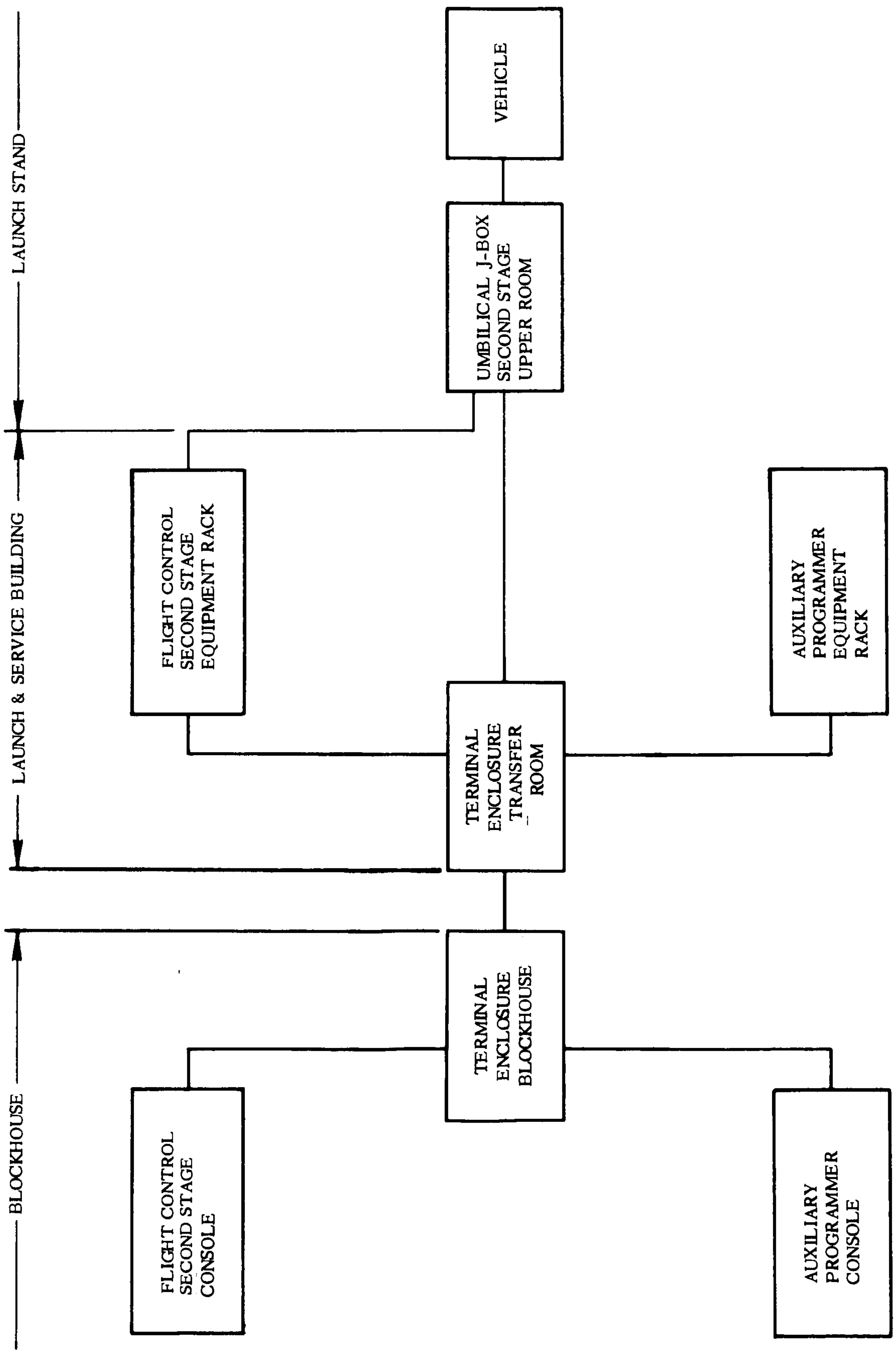


Figure 13.1-1. Block Diagram - Flight Control Second Stage

NOTE: A1, A2, ETC. IDENTIFY ENGINES

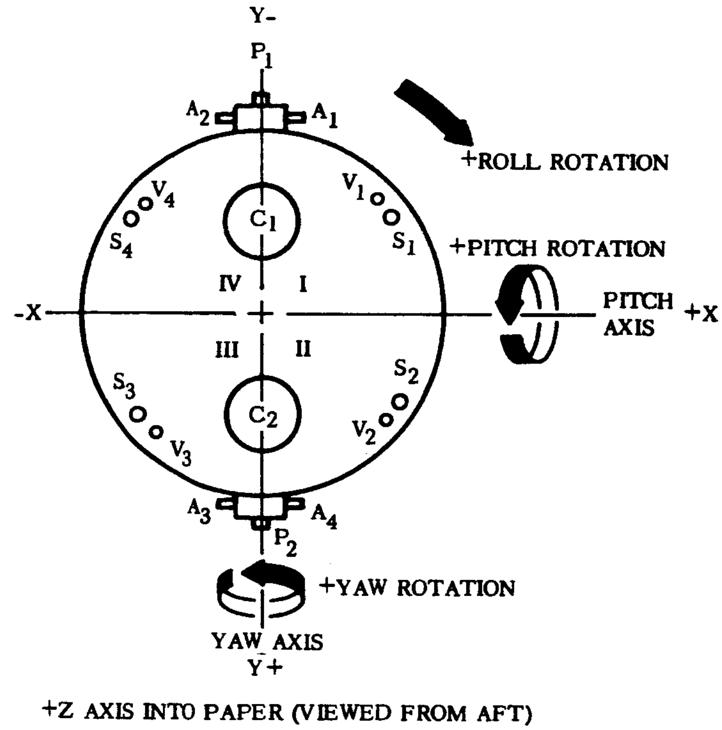


Figure 13.1-2. Centaur Vehicle Flight Control Co-ordinate System

In addition, backup circuitry is provided in the flight control subsystem for generating signals normally received from the guidance system, should the normal signal not be received by a specific time.

13.1.2 FLIGHT CONTROL GROUND SUPPORT EQUIPMENT SUBSYSTEM FUNCTION. The vehicle flight control system is tested and monitored during ground prelaunch and launch countdown operations by the flight control ground support equipment (GSE) subsystem. This GSE contains provisions for control of the vehicle flight control programmer, monitoring of programmer discrete signals, timing of discretes and other functions of the subsystem, simulation of discrete signals, signal conditioning, and both manual and automatic test of the vehicle flight control subsystem.

The flight control GSE consists of a Flight Control Second Stage console assembly, a Flight Control Equipment Second Stage rack assembly, an Auxiliary Programmer console assembly, an Auxiliary Programmer Equipment rack assembly, and a Flight Control Equipment rack assembly, plus associated cabling and wiring. Signal flow between the GSE units, and between the GSE units and the vehicle flight control subsystem is presented in Figures 13.1-4 and 13.1-5.

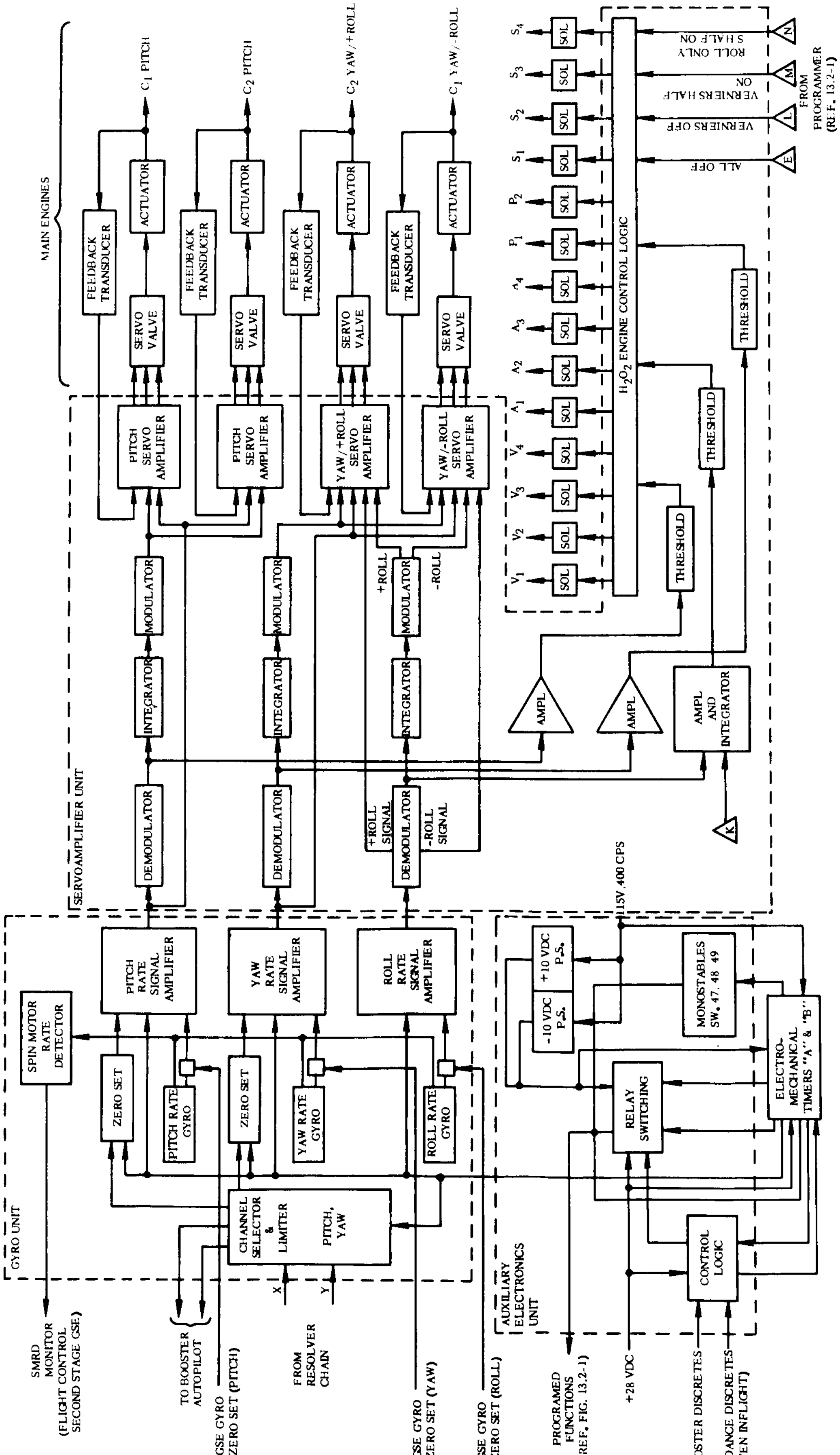


Figure 13.1-3. Block Diagram - Centaur Vehicle Flight Control (Autopilot) System

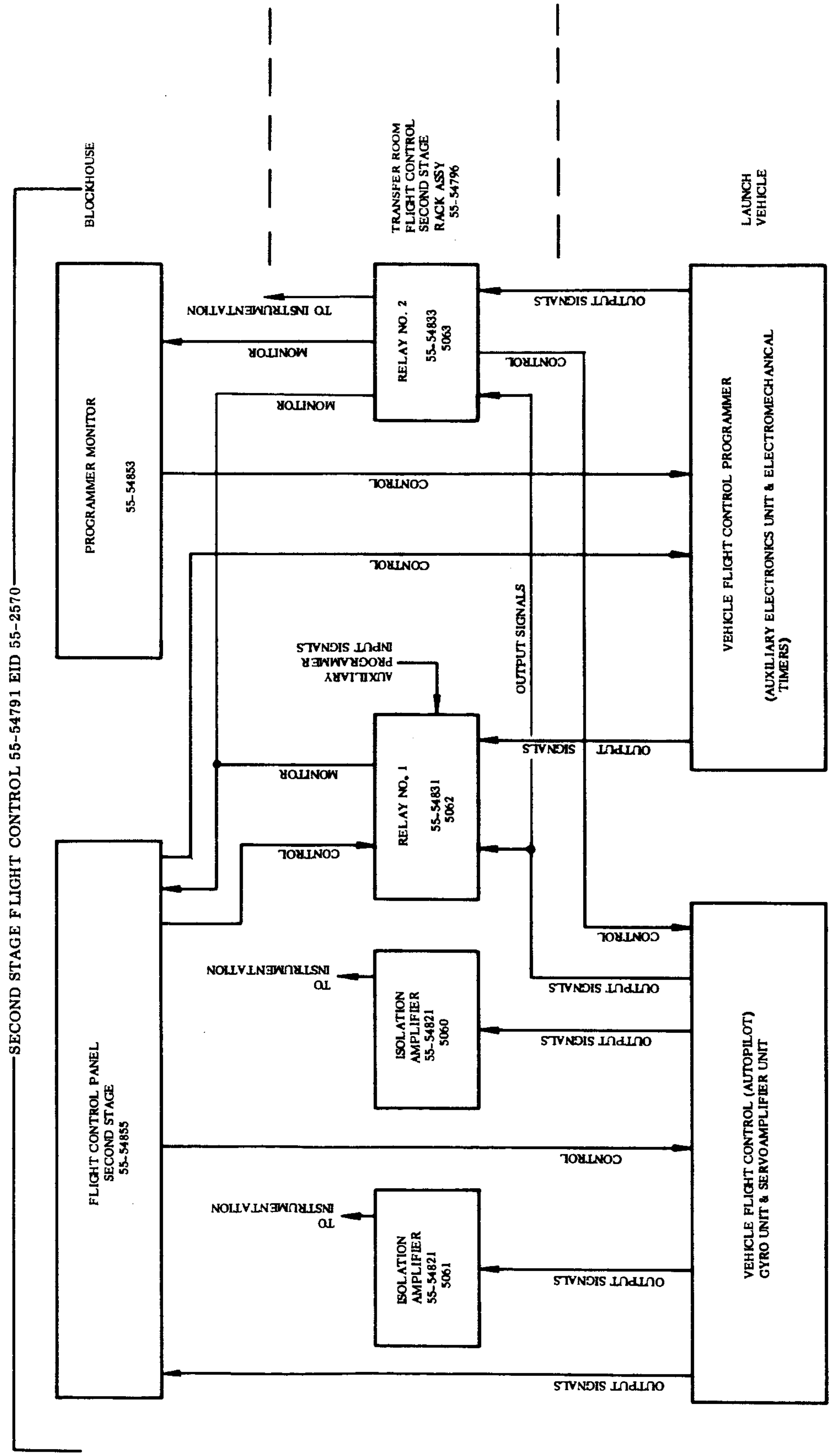


Figure 13.1-4. Block Diagram - Flight Control System GSE/Vehicle Signal Flow (Flight Control Second Stage)

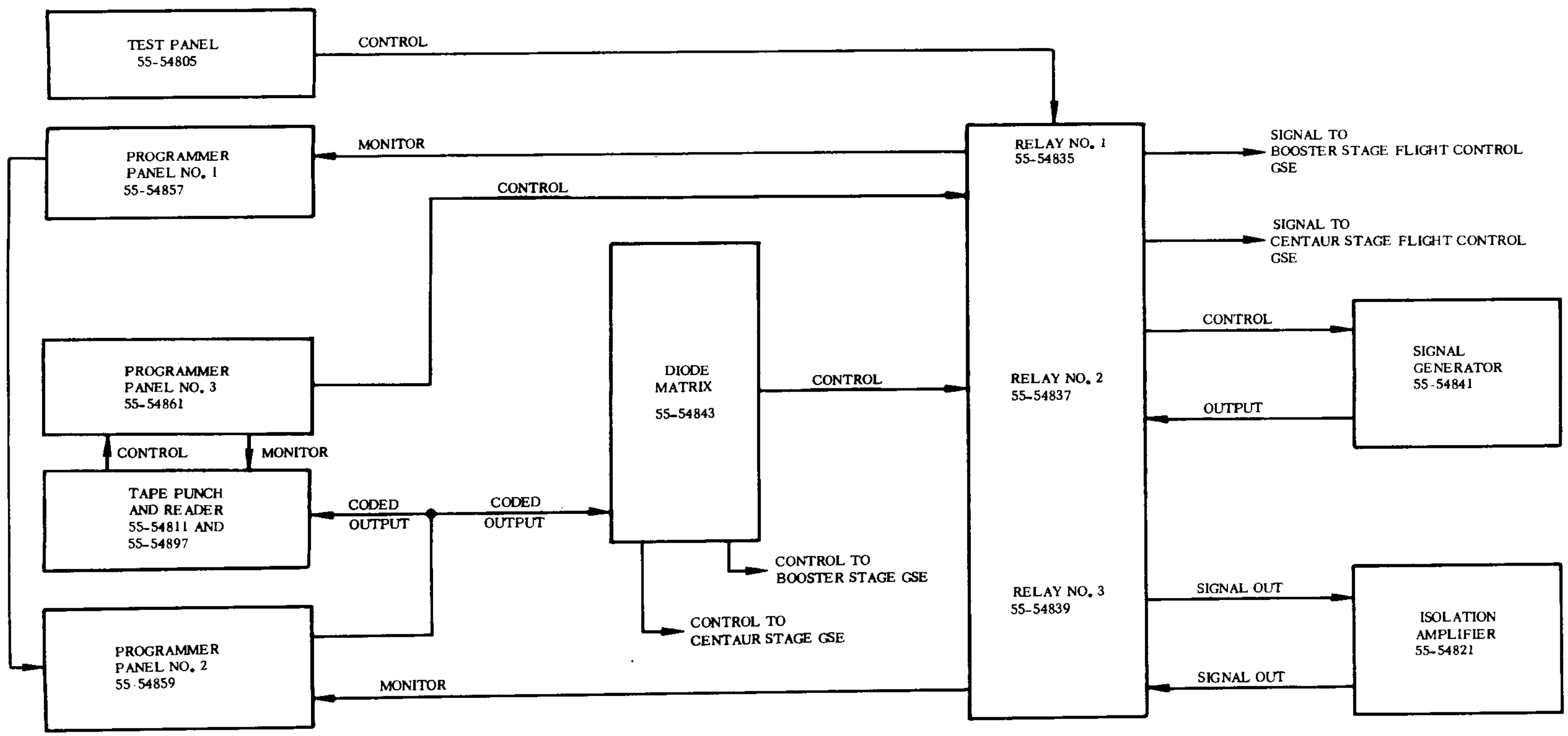


Figure 13.1-5. Block Diagram - Flight Control GSE/Vehicle Signal Flow (Auxiliary Programmer)

13.2 FLIGHT CONTROL SYSTEM MAJOR COMPONENTS

The major components of this system are herein given.

13.2.1 CENTAUR VEHICLE FLIGHT CONTROL SUBSYSTEM COMPONENTS. The vehicle flight control subsystem components are identified and explained.

13.2.1.1 Electromechanical Timers and Auxiliary Electronics Unit. Programming of flight control subsystem functions is accomplished by the electromechanical timers and an auxiliary electronics unit. A block diagram of this unit is shown in Figure 13.2-1. The auxiliary electronics unit contains logic circuits, electronic and relay switches, power supplies, and an arm-safe switch. The electromechanical timers and the auxiliary electronics unit accepts commands from the guidance system and the booster programmer, and generate switching sequences which perform the following functions:

a. Switch gain and limit level in gyro and servo packages.

b. Control guidance signal flow in gyro package.

c. Select guidance reference voltage.

d. Null integrators and control the state of engine control logic in servo unit.

e. Control Centaur stage tank pressures.

f. Relay guidance commands to the booster.

g. Control proper engine firing sequence by starting boost pumps, starting hydraulic pumps, energizing igniters, and actuating liquid oxygen and liquid hydrogen prestart and main engine valves.

h. Perform necessary switching associated with payload separation.

i. Perform necessary switching associated with other vehicle systems.

The system is accurate to within ±0.1 seconds of programmed sequence ± the error in the 400 cps power source. The timer outputs are either wired directly or actuate relays or monostables in the auxiliary electronic unit to accomplish the required switching operations.

13.2.1.2 Gyro Unit. The gyro unit is contained in a sealed package containing three rate gyros mounted to sense the Centaur vehicle angular velocities about the pitch, yaw, and roll axes. A signal amplifier is provided for each gyro. Figure 13.2-2 is a block diagram of the gyro unit. This unit provides a link between the Centaur

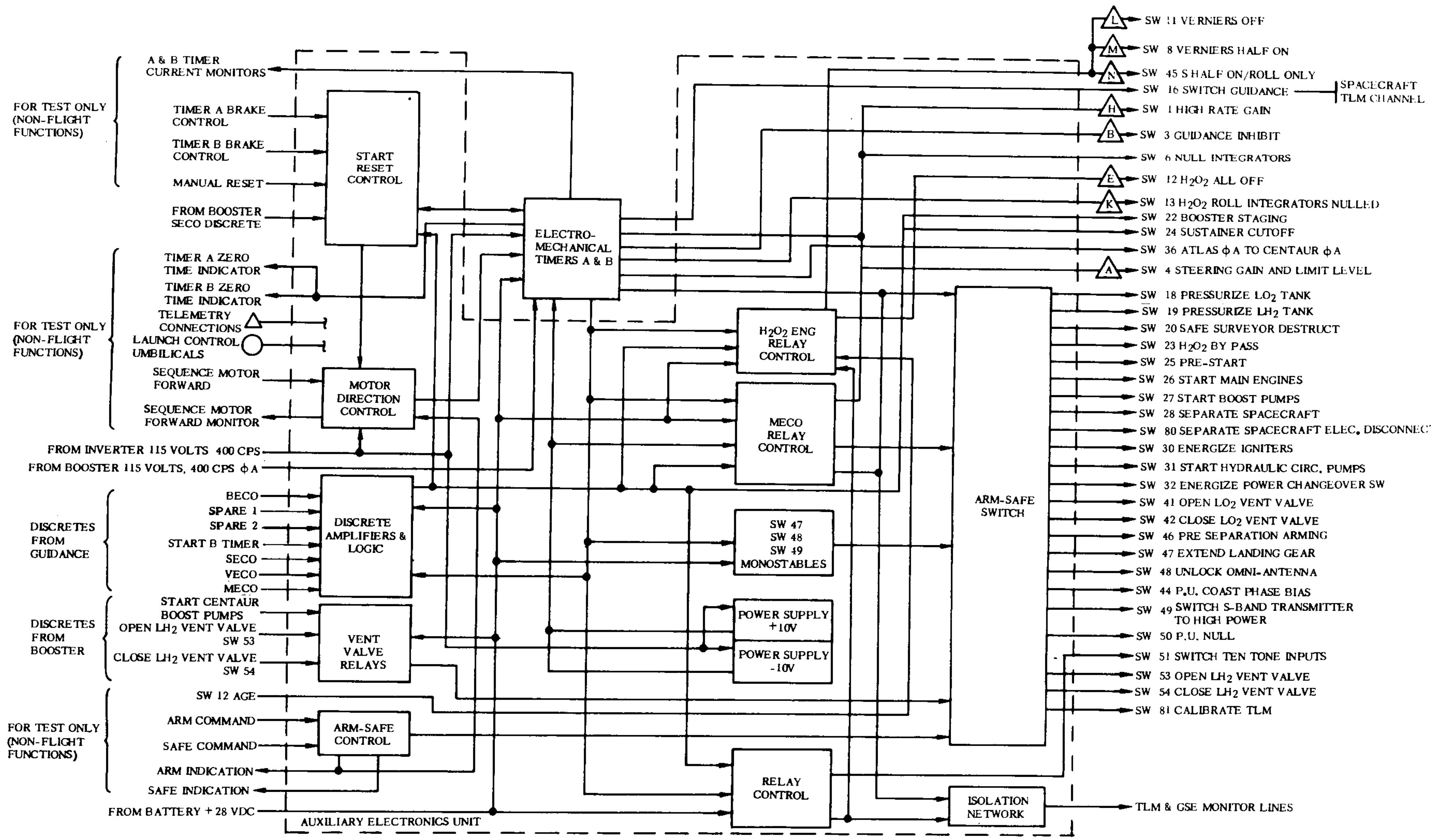


Figure 13.2-1. Block Diagram - Electromechanical Timer and Auxiliary Electronics Unit (Flight Control Programmer)

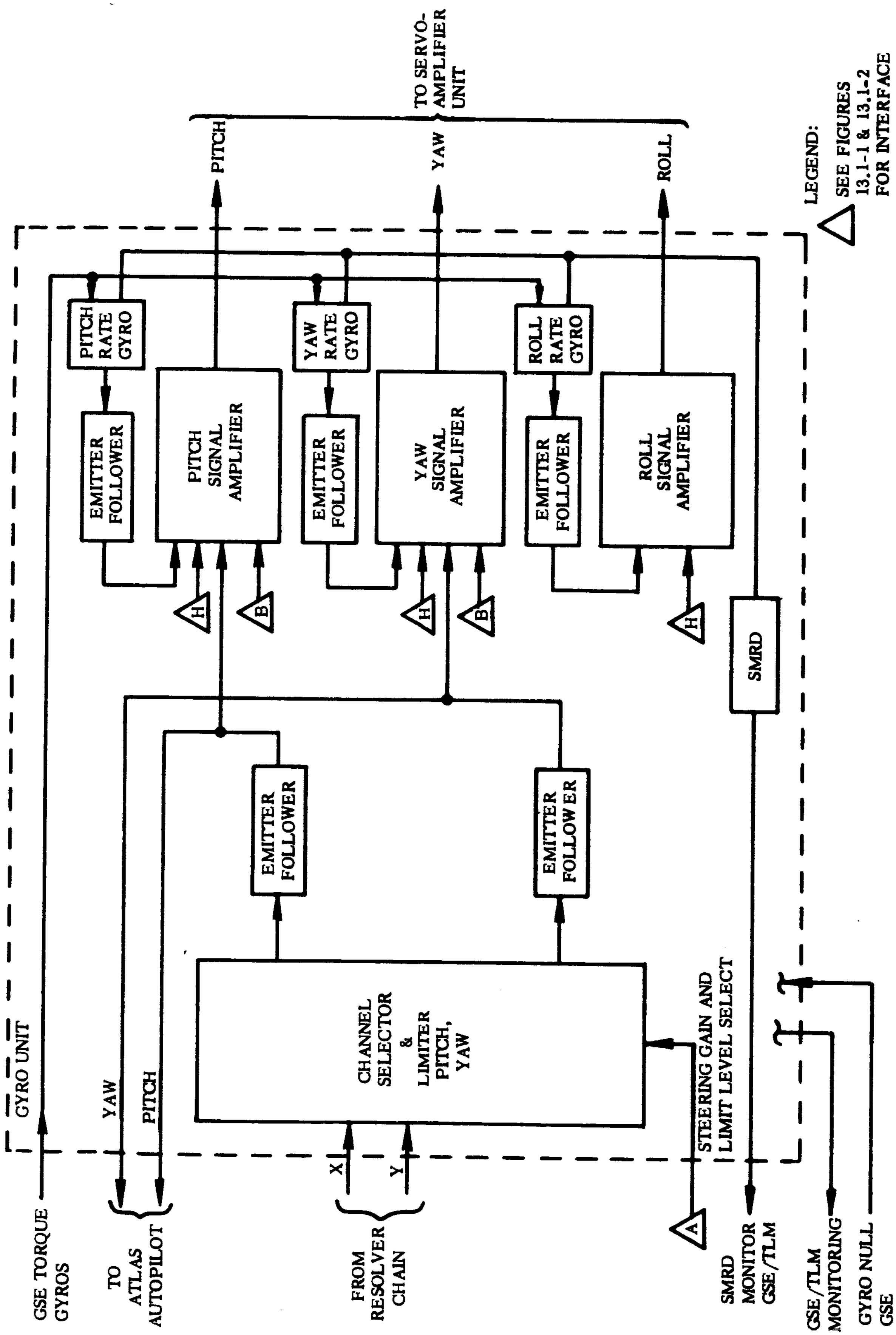


Figure 13.2-2. Block Diagram - Gyro Unit

inertial guidance system and the engine control systems. The signals provided are based on actual turning rates detected by the rate gyros for summing with displacement commands generated in the inertial guidance system. The summing of these signals results in correction signals for the engine control system. The auxiliary electronics unit provides voltage commands to the gyro unit which result in the selection of amplifier gains and the channel selector paths to carry out the modes of vehicle control for a complete mission.

The gyro unit provides 400 cps output signals which are a function of the pitch and yaw attitude and rate of turn. Roll output signals are a function of rate only. The signals vary in phase with respect to phase A of the vehicle inverter and in amplitude depending on direction and rate of turn,respectively.

13.2.1.3 Servoamplifier Unit. The servoamplifier unit accepts input signals from the gyro unit, the main engine position transducers, and the auxiliary electronics unit. It provides electrical control outputs to the main engine electro-hydraulic servovalves, and to the hydrogen peroxide attitude control and propellant settling engines. A block diagram of the servoamplifier unit, showing signal flow between components within the servoamplifier, is presented in Figure 13.2-3. The circuits, within the servoamplifier unit, condition the input signals to provide the required transfer function to the outputs.

13.2.2 FLIGHT CONTROL GROUND SUPPORT EQUIPMENT SUBSYSTEM COMPONENTS. The major components of the flight control GSE subsystem are indicated below.

13.2.2.1 Flight Control Second Stage Console Assembly, GD/C Drawing 55-54791. This console is a standard chassis mounting rack containing a Second Stage Programmer Monitor chassis assembly and control/monitor panel, GD/C Drawing 55-54853, and a Flight Control Second Stage chassis assembly and control/monitor panel, GD/C Drawing 55-54855. These components are located in the blockhouse.

13.2.2.1.1 Second Stage Program Monitor. This equipment functions as a monitor with control's and timer for the vehicle flight control programmer. Each monitored discrete can be timed in real time by selecting the respective switchlight and placing the DISCRETE STOP switch either to the TIMER position or PROG. TIMER position. With the DISCRETE STOP switch in the TIMER position, a discrete signal generated by the vehicle will stop the monitor timer only and permit the vehicle programmer to continue running. With the DISCRETE STOP switch in the PROG TIMER position, both the monitor timer and vehicle programmer will be stopped by a programmer generated discrete. The monitor panel digital clock will read in real time. Figure 13.2-4 shows the Second Stage Programmer Monitor console panel. The panel depicted is typical although the discretes monitored may change for the operational two-burn Centaur configuration (Reference GD/C AY63-0071-12, Guidance and Control Systems Requirements).

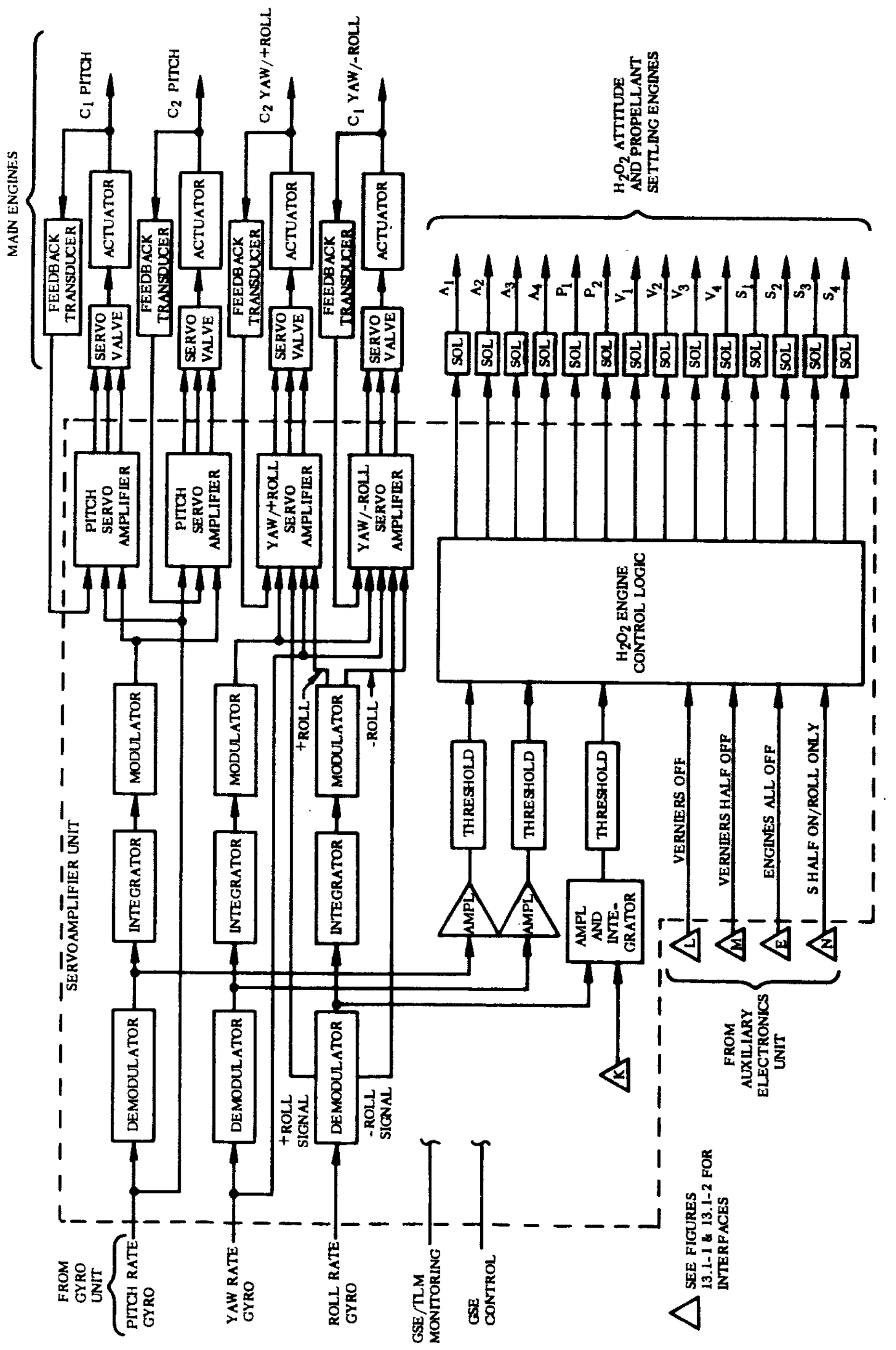


Figure 13.2-3. Block Diagram - Servoamplifier Unit

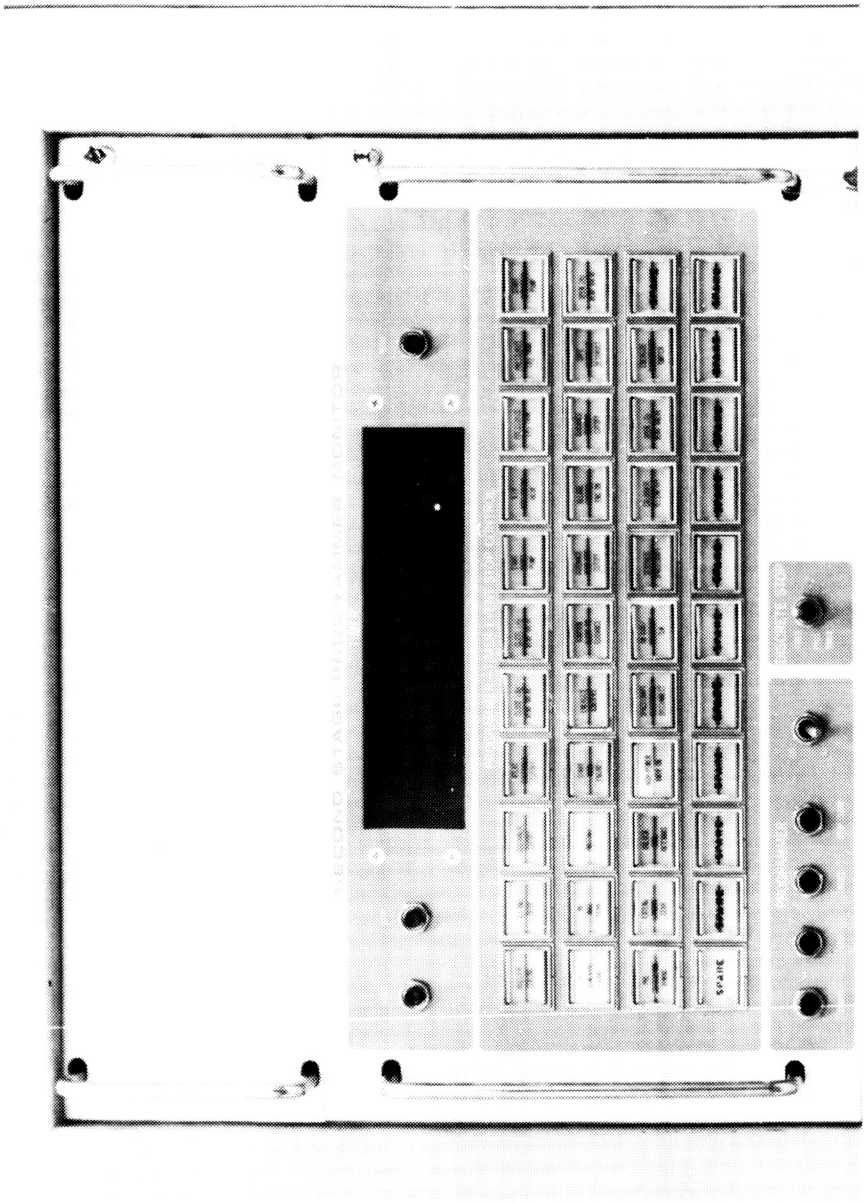


Figure 13.2-4. Second Stage Programmer Monitor Console Panel

A functional description of switches and lights on the Second Stage Programmer Monitor chassis assembly panel is given in Table 13.2-1. The signal flow between this GSE unit and the vehicle flight control subsystem is shown is Figure 13.1-3.

TABLE 13.2-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON THE SECOND STAGE PROGRAMMER MONITOR PANEL

Control or Indicator	Function
TIMER START pushbutton	Starts the timer.
TIMER STOP pushbutton	Stops the timer.
TIMER RESET pushbutton	Resets the timer to a zero position.
PROGRAMMER START pushbutton	Starts the vehicle flight control programmer.
PROGRAMMER STOP pushbutton	Stops the vehicle programmer.
PROGRAMMER RESET pushbutton	Resets the vehicle programmer to the zero position.
STOP CLEAR pushbutton	Clears the selected lights after a test is accomplished.
X1-X20 toggle switch	Selects the operating speed of the vehicle programmer during test - either normal speed or 20 times normal speed.
DISCRETE STOP - TIMER/PROG TIMER toggle switch	Provides for selection of stopping the timer alone or with the vehicle programmer.
TIMER	This is a digital clock timer which times, to the nearest second, the receipt of the vehicle programmer discretes and provides a time readout of programmer operations.

TABLE 13.2-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON THE SECOND STAGE PROGRAMMER MONITOR PANEL (Continued)

Control or Indicator	Function
PROGRAMMER - TIMER EVENT STOP CONTROL switches	There are 44 split screen switches used for discrete signal monitoring. These switches are wired so that only one discrete may be selected at one time and the selection of a second discrete cancels the first. The upper half of the indicator illuminates when the switch is depressed. The lower half illuminates only when the associated discrete signal is received at the monitor. The switch then remains illuminated until the discrete from the vehicle programmer is removed. The digital clock timer provides a visual readout for timing the occurrence of these discretes.

13.2.2.1.2 Flight Control Second Stage. This equipment functions as a monitor for the vehicle rate gyros and attitude (H_2O_2) control and propellant settling engines. Control and monitor of the flight control arm/safe switch, auxiliary control and monitor of the vehicle programmer, LH_2 vent valve control, guidance discrete simulation, vehicle hydraulic recirculation pump control, H_2O_2 roll integrators null control and system ready switch and related indicator are also provided on the panel of this chassis. Figure 13.2-5 shows a typical Flight Control Second Stage console panel.

A functional description of switches and lights on the Flight Control Second Stage chassis assembly panel is given in Table 13.2-2. The signal flow between this GSE unit and the vehicle flight control subsystem is shown in Figure 13.1-3.

13.2.2.2 Flight Control Equipment Second Stage Rack Assembly, GD/C Drawing 55-54796. This rack assembly is a standard chassis mounting rack containing the following:

a. Chassis Assembly (2) Isolation Amplifier, GD/C Drawing 55-54821.

b. Chassis Assembly Relay No. 1 Second Stage, GD/C Drawing 55-54831.

c. Chassis Assembly Relay No. 2 Second Stage, GD/C Drawing 55-54833.

d. Chassis Assembly Power Supply, GD/C Drawing 55-55630.

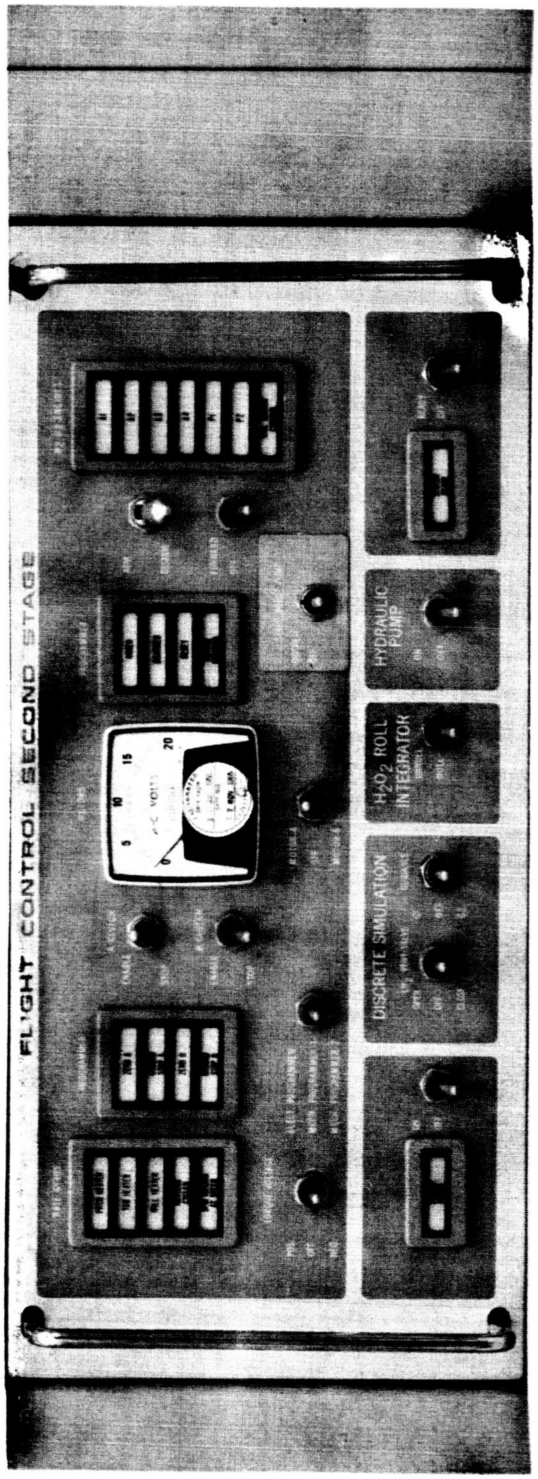


Figure 13.2-5. Flight Control Second Stage Console Panel

TABLE 13.2-2. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON CHASSIS ASSEMBLY FLIGHT CONTROL SECOND STAGE

Control or Indicator	Function
SYSTEM POWER ON/OFF toggle switch	Turns the system power on or off.
LH_2 VENT VALVE OPEN/OFF/CLOSE toggle switch	Simulates the booster programmer discretes to the 2nd stage F/C programmer.
GUIDANCE G1/OFF/G2 toggle switch	Simulates the guidance discretes to the 2nd stage F/C programmer.
H_2O_2 ROLL INTEGRATOR UNNULL/NULL toggle switch	Nulls or unnulls the H_2O_2 roll integrator.
HYDRAULIC PUMP ON/OFF toggle switch	Turns the hydraulic pump on or off.
READY/OFF toggle switch	Puts the system in the ready position. It activates the "System Ready Light" if the programmer is at zero and is armed. It is put in the "ready" position when all tests have been satisfactorily performed.
ARM/DISARM toggle switch	Puts the flight programmer in the arm/safe (active) or disarmed (passive) state. When in the former position, a signal is sent which drives the programmer arm/safe switch to the armed position; and, when in the latter position, a signal is sent which drives the programmer arm/safe switch to the safe position.
FORWARD/OFF toggle switch	Controls the state of a latching relay which reverses phases A and C to the timer motors.
A CLUTCH ENABLE/STOP toggle switch	Engages or disengages the A electro-mechanical timer motor clutch.
B CLUTCH ENABLE/STOP toggle switch	Engages or disengages the B electro-mechanical timer motor clutch.

TABLE 13.2-2. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON CHASSIS ASSEMBLY FLIGHT CONTROL SECOND STAGE (Continued)

Control or Indicator	Function
MOTOR A/OFF/MOTOR B toggle switch	Selects signal from Motor A or Motor B to be displayed on the Motor Voltage Meter.
ELECT PROGRAMMER/MECHANICAL PROGRAMMER-1/MECHANICAL PROGRAMMER-2 toggle switch	Selects GSE logic compatible with vehicle programmer configuration.
TORQUE VOLTAGE POSITIVE/OFF/NEGATIVE toggle switch	Switches the torque voltage to +28 VDC or -28 VDC and energized the torque rate gyros positive relay or the torque rate gyros negative relay respectively.
RATE GYROS PITCH HEATERS indicator	Monitors the signal from a thermostat when the pitch heater has raised the gyro temperature to the desired level.
RATE GYROS YAW HEATERS indicator	Monitors the signal from a thermostat when the yaw heater has raised the gyro temperature to the desired level.
RATE GYROS ROLL HEATERS indicator	Monitors the signal from a thermostat when the roll heater has raised the gyro temperature to the desired level.
RATE GYROS HEATERS CYCLED indicator	This light is activated when the three gyro heaters have all cycled at least once.
RATE GYROS SPIN MOTORS AT SPEED indicator	Monitors the signal sent when the rate gyros are at speed. When the rate gyros are malfunctioning, no signal is sent and the light shuts off.

TABLE 13.2-2. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON CHASSIS ASSEMBLY FLIGHT CONTROL SECOND STAGE (Continued)

Control or Indicator	Function
PROGRAMMER ZERO A indicator	Monitors the signal indicating that the "A" electromechanical timer is at zero and in the proper status for a launch.
PROGRAMMER GROUND STOP A indicator	Monitors the signal when the "A" electromechanical timer is stopped by a GSE signal.
PROGRAMMER ZERO B indicator	Monitors the signal indicating that the "B" electromechanical timer is at zero and in proper status for a launch.
PROGRAMMER GROUND STOP B indicator	Monitors the signal from the flight programmer when the B electromechanical timer is stopped by a GSE signal.
MOTOR METER voltmeter	Monitors a voltage proportional to the current flow of the motor of the electromechanical timer.
PROGRAMMER ARMED indicator	Monitors the signal when the flight programmer is armed. The signal is sent when the "Arm/Disarm Switch" is in the "arm" position.
PROGRAMMER DISARMED indicator	Monitors the signal when the flight programmer is disarmed. The signal is sent when the "Arm/Disarm Switch" is in the "disarm" position.
PROGRAMMER RESET indicator	Monitors the signal from the inhibit circuit on the flight vehicle when the programmer is not at zero.

TABLE 13.2-2. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON CHASSIS ASSEMBLY FLIGHT CONTROL SECOND STAGE (Continued)

Control or Indicator	Function
PROGRAMMER MOTORS FORWARD indicator	Monitors the signal from the flight programmer which indicates that the timer motors will run in the forward direction.
H_2O_2 ENGINES A1 indicator	Monitors the discrete from the flight control servoamplifier when the A1 engine is on.
H_2O_2 ENGINES A2 indicator	Monitors the discrete from the flight control servoamplifier when the A2 engine is on.
H_2O_2 ENGINES A3 indicator	Monitors the discrete from the flight control servoamplifier when the A3 engine is on.
H_2O_2 ENGINES A4 indicator	Monitors the discrete from the flight control servoamplifier when the A4 engine is on.
H_2O_2 ENGINES P1 indicator	Monitors the discrete from the flight control servoamplifier when the P1 engine is on.
H_2O_2 ENGINES P2 indicator	Monitors the discrete from the flight control servoamplifier when the P2 engine is on.
H_2O_2 ENGINE LIGHTS V_1, V_2, V_3, V_4, S_1, S_2, S_3, and S_4 indicators	These lights are a part of the operational Centaur 2-burn configuration. These lights are not shown in Figure 13.2-5.
H_2O_2 ENGINES-ENGINE SYSTEM CONTROL indicator	Monitors the times during which the H_2O_2 engines are being externally controlled from the engine system GSE.

TABLE 13.2-2. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON CHASSIS ASSEMBLY FLIGHT CONTROL SECOND STAGE (Continued)

Control or Indicator	Function
SYSTEM READY indicator	Illuminates when the system is in a ready state. This occurs when the "Ready/Off Switch" is in the "ready" position, providing the programmer is at zero and the "Armed/Disarmed Switch" is in the armed position.
SYSTEM POWER indicator	Illuminates when the system power is on.

These components an located in the transfer room of the Launch and Service Building. A block diagram of this equipment and associated control chassis in the blockhouse is presented in Figure 13.2-6. Also shown is the electrical power input requirements.

13.2.2.2.1 Chassis Assembly Isolation Amplifiers. These two amplifiers are used to drive the long run lines from the transfer room to the blockhouse with a minimum phase shift. These amplifiers also serve to isolate the GSE from the vehicle flight control subsystem.

13.2.2.2.2 Chassis Assembly Relay No. 1 Second Stage. The relays in this chassis are used to control signals from the auxiliary programmer to the vehicle flight control subsystem and also to control monitor circuits within the GSE/vehicle subsystems. Some relays are controlled by electronic switches designed to present a minimum load to the output circuits of the vehicle flight control subsystem and the auxiliary programmer.

13.2.2.2.3 Chassis Assembly Relay No.2 Second Stage. The relays and electronic switches in this chassis are associated with control of the discrete signals originating from the vehicle flight control programmer. Other circuits include engine function monitors and control of the vehicle programmer.

13.2.2.2.4 Chassis Assembly Power Supply. This chassis assembly contains four DC power supply circuits which supply -5 vdc, -10 vdc, +10 vdc and -28 vdc to the flight control GSE subsystem through Chassis Assembly Relay No. 1 and No. 2.

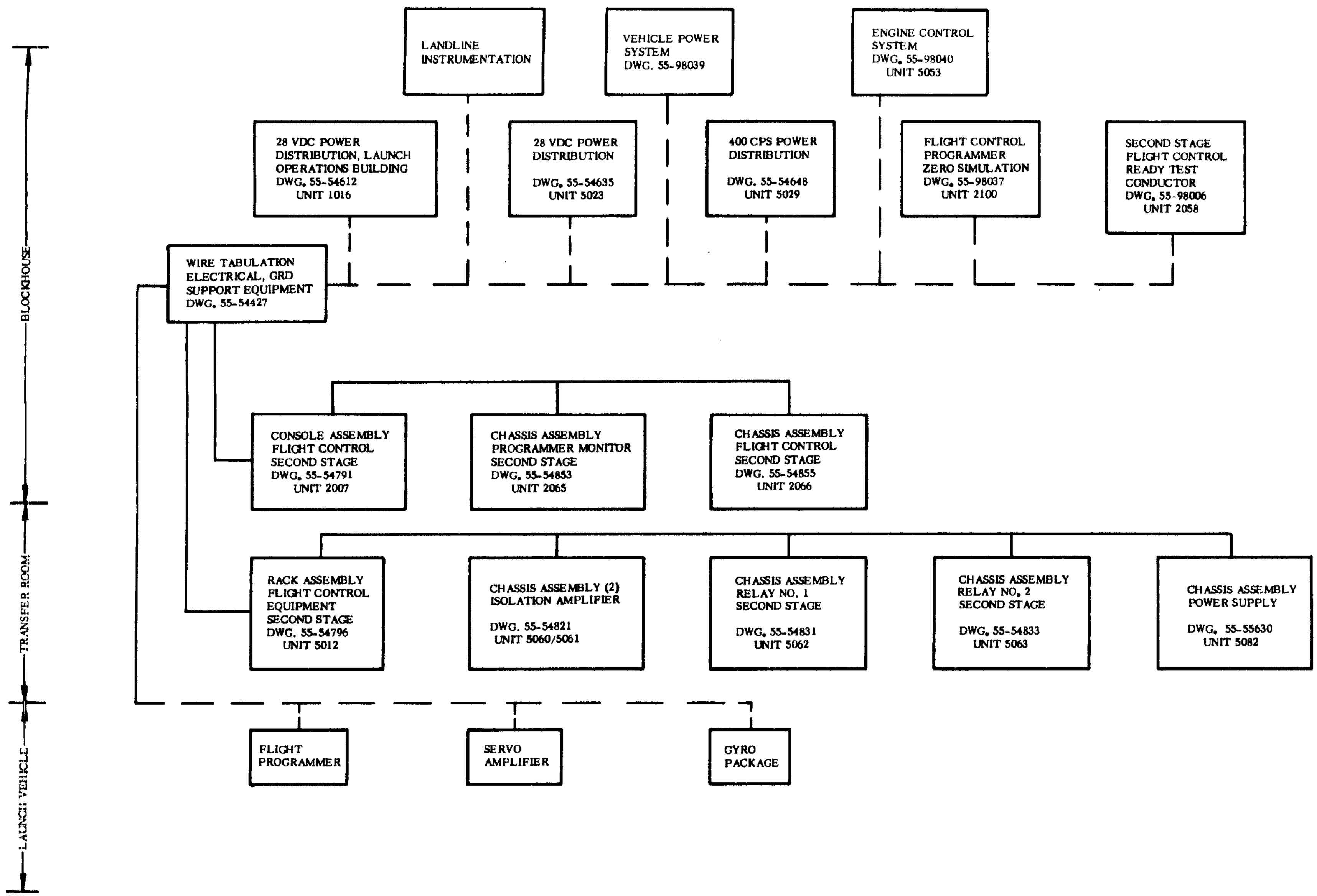


Figure 13.2-6. Block Diagram - Flight Control Second Stage GSE Subsystem

13.2.2.3 Auxiliary Programmer Console Assembly, GD/C Drawing 55-54792. This console is a standard chassis mounting rack containing three Programmer Chasis Assemblies (GD/C Drawings 55-54857, 55-54859 and 55-54861) and a Chassis Assembly-Tape Reader, GD/C Drawing 55-54897. These components are located in the blockhouse.

The Auxiliary Programmer subsystem function is to provide properly conditioned test signals to the vehicle flight control subsystem during ground checkout of this subsystem. The test signals may be generated manually or recorded on punched tape to be used in an automatic test sequence. A typical auxiliary programmer control console is shown in Figure 13.2-7.

13.2.2.3.1 Chassis Assembly Programmer No. 1. The controls on this chassis assembly panel are used to select the type and magnitude of output signal desired.

13.2.2.3.2 Chassis Assembly Programmer No. 2. This chassis assembly and controls are used to select test functions. Output test signals from this chassis or chassis No. 1 may be used in the selected test function.

13.2.2.3.3 Chassis Assembly Programmer No. 3. This chassis assembly and panel provides for control of a-c and d-c input power to the auxiliary programmer output, selection of vehicle stage for test and control of the test tape punch and reader circuits.

13.2.2.3.4 Chassis Assembly Tape Reader. This unit is used to read prepunched tapes for automatic testing. The output of this unit is fed to the diode matrix for decoding and switching to the indicated relays (see Figure 13.1-4).

A functional description of switches and lights on the Auxiliary Programmer console panels is given in Table 13.2-3. The signal flow between the console chassis and the remaining auxiliary programmer subsystem shown in Figure 13.1-4.

13.2.2.4 Auxiliary Programmer Equipment Rack Assembly. This rack assembly is a standard chassis mounting rack containing the following component chassis assemblies: Chassis Assembly - Relay No. 1 Auxiliary Programmer, Drawing 55-54835; Chassis Assembly - Relay No. 2 Auxiliary Programmer, Drawing 55-54837; Chassis Assembly - Relay No. 3 Auxiliary Programmer, Drawing 55-54839; Chassis Assembly - Isolation Amplifier, Drawing 55-54821; Chassis Assembly - Signal Generator Drawing 55-54841; and Chassis Assembly - Diode Matrix, Drawing 55-54843. These components are located in the transfer room. A block diagram of this equipment and associated control chassis in the blockhouse is shown in Figure 13.2-8.

13.2.2.4.1 Chassis Assembly - Relay No. 1. This chassis contains relay logic circuits that control the signal paths from two multi-tapped transformers. These signals are chosen by switch selection from Programmers No. 1 and No. 2 chassis which drive the diode matrix. The matrix, in turn, controls the proper relays.

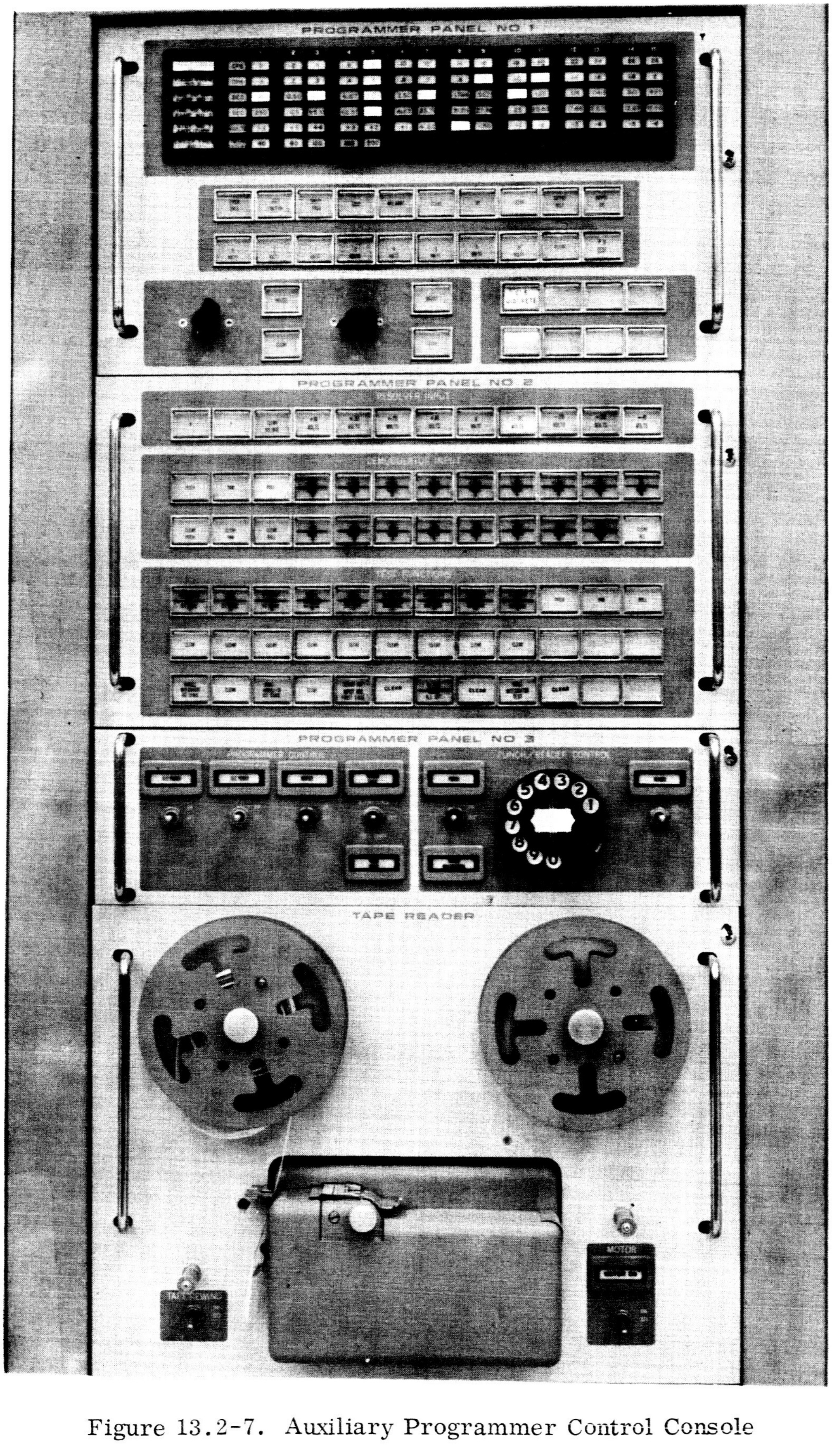


Figure 13.2-7. Auxiliary Programmer Control Console

TABLE 13.2-3. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON AUXILIARY PROGRAMMER SYSTEM

Control or Indicator	Function
PROGRAMMER PANEL NO. 1	
FIXED FREQUENCY switch light NOTE: These lights will not illuminate until the appropriate SELECT switch lights are depressed.	Depressing this switch illuminates the FIXED FREQUENCY NUMBER 1, FIXED FREQUENCY NUMBER 2 and CPS lights. This generates a 400 cps carrier modulated at a pre-selected frequency. The magnitude of the peak voltage selected is 0, 0.5, 1, 2, 3, 4, 5, or 6 volts, depending on which of the bottom row of switch lights is depressed. The voltage can be doubled by depressing the X2 switch. The frequency is chosen by using either rotary switch No. 1 or No. 2. Rotary switch No. 1 selects frequencies from 0 to 28 cps and rotary switch No. 2 selects frequencies from 0.1 to 2 cps. When a frequency from row 2 is used, switch 1 must also be used. Since the two rows are cumulative, unless the sum of the two rows is desired, switch 1 should be rotated to position 1. The SELECT switch lights, to the right of each rotary switch, are used to select the frequency after the rotary switches are in the correct position. Both SELECT switches must be pushed if a selection from the second row is desired. The CLEAR switch light to the right of the 6 VOLT switch light is used to clear the voltage commands. The CLEAR switch light to the right of the X2 switch light clears the X2 command. The CLEAR switch light to the right of the NEG. RAMP switch light is used to clear the FIXED FREQUENCY command and reset the lights.

TABLE 13.2-3. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON AUXILIARY PROGRAMMER SYSTEM (Continued)

Control or Indicator	Function
PROGRAMMER PANEL NO. 1 (Continued)	
	The CLEAR switch lights to the right of the rotary switch are used to clear the associated rotary switch.
STEP FUNCTION switch light NOTE: These lights will not illuminate until the SELECT switch light for rotary switch No. 1 is depressed.	Depressing this switch, lights the STEP NUMBER 1 AMPLITUDE light and VOLTS light. Rotating rotary switch No. 1 selects a step voltage amplitude from +6 volts. Pressing the SELECT switch to the right of the rotary switch commands the selected voltage. This generates a 400 cps carrier modulated by the Step Function. The STEP FUNCTION switch is cleared by the CLEAR switch light to the right of the NEG. RAMP switch light.
SWEEP FREQUENCY switch light NOTE: These lights will not illuminate until the SELECT switch light for rotary switch No. 1 is depressed.	Depressing this switch, lights the SWEEP FREQUENCY NO. 1 and TOTAL CYCLES lights. This generates a 400 cps carrier modulated by a sweep frequency. The total cycles of the modulated signal is determined rotary switch No. 1, which is used to select 40, 80, 120, 160, or 200 cycles. The magnitude of the voltage of the signal is selected from 0 to 6 volts by depressing one of the lower row of switch lights. Double magnitude can be obtained by pressing the X2 switch light. The SWEEP FREQUENCY command is cleared by the CLEAR switch light to the right of the NEGATIVE RAMP switch light.

TABLE 13.2-3. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON AUXILIARY PROGRAMMER SYSTEM (Continued)

Control or Indicator	Function
PROGRAMMER PANEL NO. 1 (Continued)	
RAMP switch light NOTE: These lights will not illuminate until the appropriate SELECT switch lights are depressed.	Depressing this switch, lights the TIME TO MAX RAMP NUMBER 1 and TIME TO MAX RAMP NUMBER 2 and SEC lights, and generates a 400 cps signal with an amplitude that increases in time. The lower row of switch lights is used to select the magnitude for the peak voltage of the ramp. Rotary switches No. 1 and No. 2 are used to select the slope of the ramp. A time to max. ramp is available from 0 to 262.5 seconds. When a time from row 2 is used, switch 1 must also be used. Since the two rows are cumulative, unless the sum of the two rows is desired, switch 1 should be rotated to position 1. The SELECT switches for both rotary switches must be used when dial 2 is used. The ramp command is cleared by the CLEAR switch light to the right of the NEG. RAMP switch light.
NEGATIVE RAMP switch light NOTE: These lights will not illuminate until the appropriate SELECT switch lights are depressed.	Depressing this switch, lights the TIME TO MAX. RAMP NO. 1 and TIME TO MAX. RAMP NO. 2 and SEC lights and generates a 400 cps negative ramp signal. It is similar to the positive ramp signal except for the sign of the signal.
OUTPUT HOLD switch light	Pressing this switch prevents Auxiliary Programmer signals from leaving the system even though the OUTPUT switch on Programmer Panel No. 3 is on. This is generally used when punching a tape.

TABLE 13.2-3. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON AUXILIARY PROGRAMMER SYSTEM (Continued)

Control or Indicator	Function
PROGRAMMER PANEL NO. 1 (Continued)	
OUTPUT ON switch light	Pressing this switch clears the OUTPUT HOLD command and allows Auxiliary Programmer commands to enter the Autopilot System. It is generally used with the Programmer Panel No. 3 OUTPUT switch OFF, for punching tapes, to coordinate signals on the tape.
PROGRAMMER PANEL NO. 2	
RESOLVER INPUT switch lights	Switch lights in this module allow for a selection of either X or Y resolver input or both with a voltage input selection ranging from 0 to +1.65 and -1.65 volts. Both X and Y can be selected, but only one voltage can be selected at a time. The CLEAR VOLTAGE switch light is used to clear the Resolver Input.
DEMODULATOR INPUT switch lights	Switch lights in this module allow for a selection of any combination of PITCH, YAW or ROLL Demodulator Inputs. The input voltage for each can be selected as 0, +.45, +.50, +.55, +.61, +.70, +.75, +.80, +1.25 volts or the negative values of these voltages. Each channel, PITCH, YAW, or ROLL can be cleared individually by the CLEAR switch light located beneath it or they can all be cleared together by using the CLEAR ALL switch light.
TEST FUNCTIONS switch lights	Switch lights in this module allow for a selection from the following test functions: a. Integrator Test Booster Stage

TABLE 13.2-3. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON AUXILIARY PROGRAMMER SYSTEM (Continued)

Control or Indicator	Function
PROGRAMMER PANEL NO. 2 (Continued)	
	b. Gyro Test Booster Stage c. Gyro Amp Enable Booster Stage d. Enable Rate Gyro Booster Stage e. Enable Rate Gyro Centaur Stage f. Signal Amp Output Grd. Centaur Stage g. Integrator Unnull Centaur Stage h. Servo Amp Input Grd. Centaur Stage i. Servo Amp Input Centaur Stage j. Unnull Integrator Booster Stage k. Gyro Unnulled Booster Stage Each of the test functions has an individual CLEAR switch light either directly below it or to the immediate right of it. Each of the test functions can be modified by a PITCH, YAW, or ROLL command. Any number of the test functions can be chosen to run simultaneously.
PROGRAMMER PANEL NO. 3	
DC POWER ON switch	This switch controls +28 vdc power to the Auxiliary Programmer System. When it is on facility +28 vdc is provided to the system and the DC POWER light is illuminated.

TABLE 13.2-3. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON AUXILIARY PROGRAMMER SYSTEM (Continued)

Control or Indicator	Function
PROGRAMMER PANEL NO. 3 (Continued)	
AC POWER ON switch	This switch turns on 115 vac 400 cps power to the Auxiliary Programmer system. When it is on, it illuminates the AC POWER light.
OUTPUT ON switch	When the OUTPUT switch is in the OFF position the Programmer Console is isolated from the other systems. This position is used to punch and proofread a tape. When it is in the ON position, the OUTPUT light is illuminated and the programmer can transmit commands to the airborne equipment.
SECOND STAGE/FIRST STAGE selector switch	This switch selects either the booster or Centaur for programmer outputs. SECOND STAGE and FIRST STAGE lights indicate which has been selected.
PUNCH OFF-ON switch	This switch is used to start the Tape Punch. The PUNCH light indicates when it is on. In case of a Punch malfunction, the PUNCH MALFUNCTION light turns on and interrupts the control signal to the Punch Assembly.
TAPE ADVANCE switch	The TAPE ADVANCE dial is a rotary dial with ten (10) divisions used to advance the tape during the punching operation, when selecting a time for duration of the event. Each number on the dial represents a time base of one-tenth of a seconds.
READER OFF-ON switch	This switch supplies +28 volts to the Reader to start the tape through it and illuminates the READER light.

TABLE 13.2-3. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON AUXILIARY PROGRAMMER SYSTEM (Continued)

Control or Indicator	Function
TAPE READER PANEL	
MOTOR ON-OFF switch	This switch provides 115 vac 400 cps power to the Reader Assembly motor to turn it ON. In the ON position, MOTOR ON light is illuminated. No AC power will be provided until the DC POWER and AC POWER switches on Programmer Panel No. 3 are also ON.
TAPE REWIND switch	This switch provides 115 vac neutral to the Tape Reader rewind motor to rewind the tape.

13.2.2.4.2 Chassis Assembly - Relay No. 2. This chassis contains the relays which are controlled by switches No. 1 and No. 2 on the Programmer Panel No. 1. These relays are driven by signals through the diode matrix and controlled by the OUTPUT and FIRST STAGE/SECOND STAGE switches on the Programmer Panel No. 3.

13.2.2.4.3 Chassis Assembly - Relay No. 3. This chassis contains the relays that are driven by the diode matrix and are controlled by the output from the switches on Programmer Panel No. 2 through the diode matrix.

13.2.2.4.4 Chassis Assembly - Isolation Amplifier. This amplifier is used to drive the long run lines and provide impedance matching.

13.2.2.4.5 Chassis Assembly - Signal Generator. This chassis contains the circuitry and hardware that supplies the types of signals indicated on Programmer Panel No. 1. These signals, controlled by panel switches, are fed through the diode matrix which in turn controls the proper relays.

13.2.2.4.6 Chassis Assembly - Diode Matrix. This chassis contains the diode matrix that accepts the coded inputs from the Reader assembly or the coded output from the two programmer panels. This matrix, in turn, drives the proper relays that select signals and circuits for these signals.

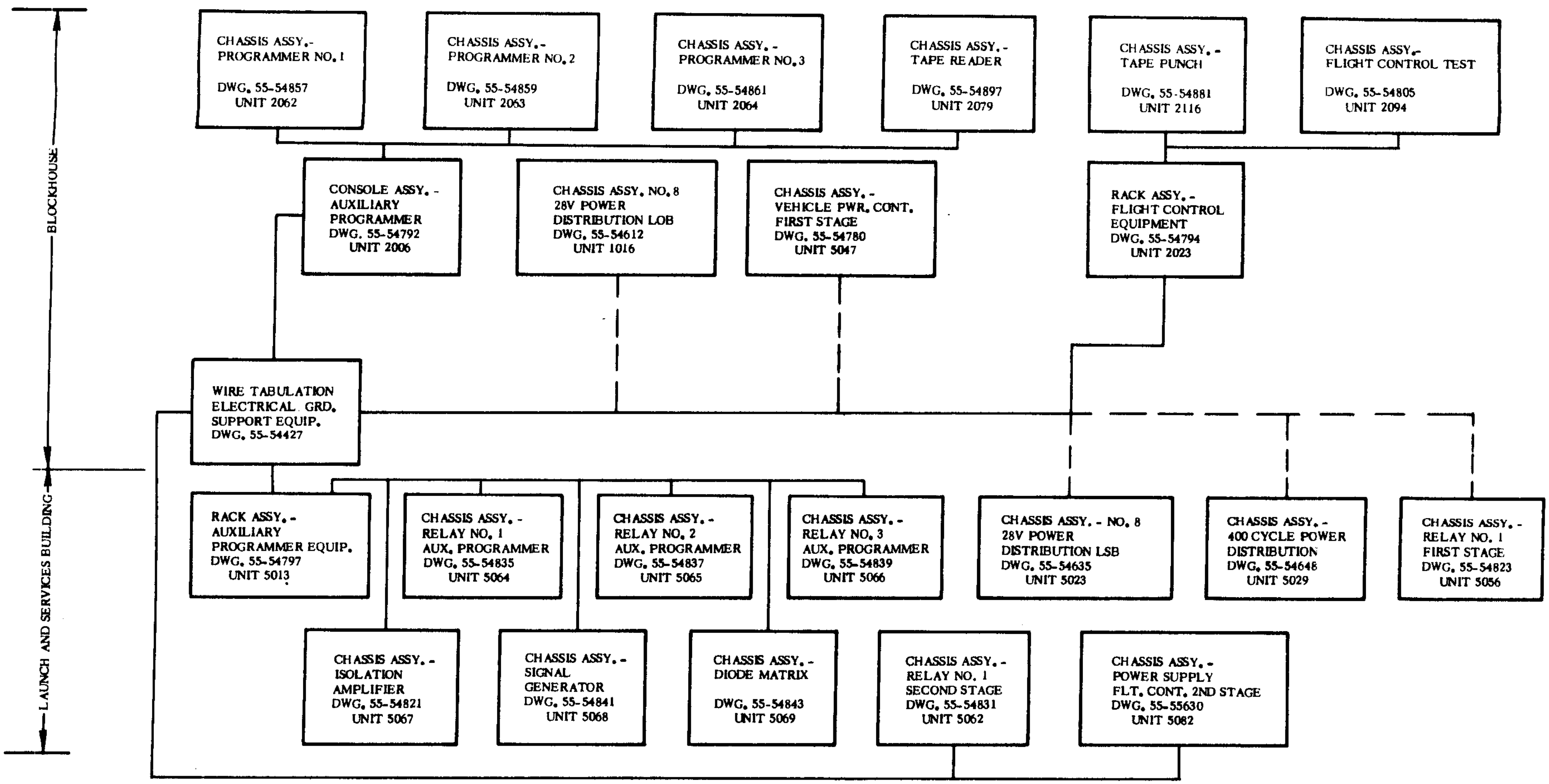


Figure 13.2-8. Block Diagram - Flight Control Second Stage GSE Subsystem (Auxiliary Programmer)

13.2.2.5 Flight Control Equipment Rack Assembly. This rack assembly, located in the blockhouse, contains a Chassis Assembly - Tape Punch, GD/C Drawing 55-54881, and a Chassis Assembly - Flight Control Test, GD/C Drawing 55-54805. The signal flow from these units to associated units in the flight control GSE is shown in Figure 13.1-4. These two chassis are also shown in the block diagram of GSE hardware components, Figure 13.2-8.

13.2.2.5.1 Chassis Assembly - Tape Punch. This unit is used to punch signals in code on the tape used for automatic testing.

13.2.2.5.2 Chassis Assembly - Flight Control Test. This chassis is used to control test of roll set, engine position, circuit test, static gain, feedback monitor, threshold and gain, and torque rate gyros.

13.2.3 FLIGHT CONTROL SUBSYSTEM SIGNAL INTERFACES FOR CENTAUR. The following signals go from the Flight Control Second Stage subsystem to the Auxiliary Programmer subsystem:

a. Enable rate gyro - pitch, yaw and roll.

b. Signal amplifier output ground - pitch, yaw and roll.

c. Integrator Un-null - pitch, yaw and roll.

d. Servoamplifier input volt - pitch, yaw and roll.

e. (-) 5 vdc.

The following signals go from the Auxiliary Programmer subsystem to the Flight Control Second Stage:

a. Signal Amplifier output ground - pitch, yaw and roll.

b. Signal Amplifier output ground clear.

c. Integrator Un-null - pitch, yaw and roll.

d. Clear Integrator un-null.

e. Enable rate gyro - pitch yaw and roll.

f. Clear enable rate gyro

g. Servoamplifier input volt - pitch, yaw and roll.

h. Clear servoamplifier input ground.

i. Resolver chain output signals - X and Y.

13.2.4 ELEMENTARY SCHEMATIC. The Centaur flight control ground support equipment design is found in detail in the GD/C Drawing 55-98042, an elementary schematic diagram.

13.3 CHECKOUT

The initial checkouts of the flight control GSE are in the form of validations of the subsystems, normally end to end type validation. Once the subsystems are validated as satisfactory, only changes in system circuitry or components will necessitate a revalidation of that particular subsystem. There are, however, periodical calibrations required for the isolation amplifiers and the power supplies. Validations and calibrations are performed to approved and published Centaur test procedures.

SECTION XIV

GUIDANCE SYSTEM

14.1 VEHICLE GUIDANCE SYSTEM

The design objective of the Centaur vehicleborne Missile Guidance System (MGS) is to achieve a trajectory accuracy such that the required spacecraft midcourse velocity correction is within the limits specified for the mission. Midcourse velocity correction may be defined as that velocity correction necessary, at 20 hours from injection, to correct the trajectory for lunar target miss only (for engineering missions) or for lunar target miss plus time of flight (for operational missions). Also included in the velocity correction are corrections for unbraked impact velocity, spacecraft-induced errors, or any other lunar trajectory parameter.

14.1.1 GUIDANCE SYSTEM FUNCTION. The missile guidance system is capable of performing the following functions during flight:

a. Provide a gyro-stabilized three-axis orthogonal reference system for the measurement of the vehicle acceleration in inertial coordinates.

b. Provide continuous steering signals to the Booster and Centaur flight control (autopilot) systems.

c. Provide coordinate transformation of the steering signals from platform coordinates to vehicle coordinates referenced to vehicle pitch, yaw, and roll axes. Only pitch and yaw components are provided in the output from the system.

d. Provide discrete signals to the Centaur autopilot auxiliary electronics unit.

e. Provide required temperature control for the guidance system inertial sensors within the stable platform.

f. Distribute and condition the power required for operation of the various guidance components. This power is obtained from the vehicle electrical system (see Section XII, Paragraph 12.1.1, this report).

g. Provide telemetry output of digital data-link words at the rate of 800 bits per second and scaled analog outputs.

14.1.2 GUIDANCE SYSTEM COMPONENTS. The MGS consists of an inertial platform, a platform electronics unit, a signal conditioner, a navigation computer, and a pulse rebalance unit. The functional relationship of these components is shown in the form of a block diagram in Figure 14.1-1. Cursory descriptions of each of these components are contained in the following paragraphs. For a detailed description of

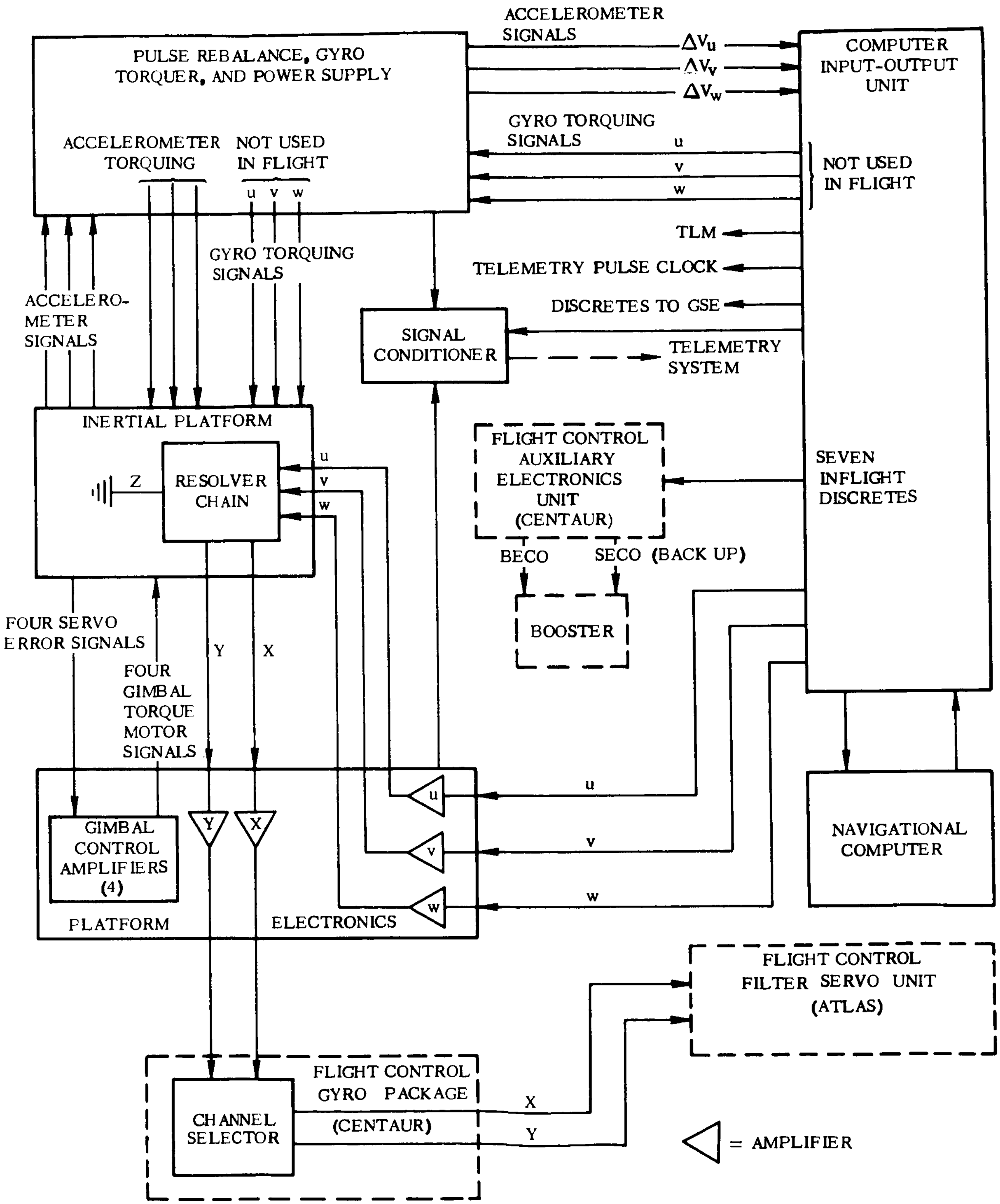


Figure 14.1-1. Block Diagram-Guidance System

these component functions functions refer to "Centaur Technical Handbook," Convair Report No. GD/A-BPM64-001-1.

14.1.2.1 Inertial Platform. The inertial platform within which are mounted three single-degree-of-freedom rate integrating gyros, functions in conjunction with the platform electronics to provide a stable inertial reference for three pendulous pulse-rebalanced accelerometers. Circuitry is included within the platform for temperature control of the inertial components and preamplification of the inertial component output signals. The platform provides for coordinate transformation of the steering signals received from the navigation computer by means of four 400 cycle a-c resolvers attached to the gimbal structure.

14.1.2.2 Platform Electronics. The platform electronics unit contains the electronic components and circuitry required to support the following functions:

a. Stabilization of the platform inner gimbal about the four gimbal axes.

b. Switching for caging and coarse aligning the platform gimbals.

c. Phase reversal of the No. 4 gimbal stabilization signal when the vehicle pitch angle exceeds a 90-degree position from the horizontal flight attitude.

d. Isolation and amplification for the signals transmitted through the platform coordinate transformation chain.

e. Routing of certain platform signals to and from the guidance system components.

14.1.2.3 Signal Conditioner. The signal conditioner provides the demodulators, scaling, and other electronic circuitry necessary to modify the guidance system signals to be compatible with the standard PAM/FM/FM telemetering techniques used by the Centaur telemetry system.

14.1.2.4 Navigational Computer. During flight, the navigational computer solves the guidance equations required for continual two-coordinate control discretes. The computer performs the following modes during prelaunch operations:

a. Computer and guidance system checkout

b. Inertial component calibration and platform alignment

c. Self order-test routine during all phases of operation.

The computer performs in a guidance mode (providing steering signals and discretes) during vehicle flight.

The navigation computer is a binary, fixed point, serial, general purpose, digital machine. The computer consists of two basic sections: a memory section and an input-output section.

14.1.2.5 Pulse Rebalance Unit. The pulse rebalance unit distributes the voltages and currents necessary to operate the guidance system. It contains the electronics for pulse rebalancing the inertial platform's three pendulous accelerometers.

In addition, the pulse rebalances unit contains the electronics necessary to generate electrical pulses which represent changes in vehicle velocity. These precision pulses are sent to the navigational computer where they are used to solve guidance equations.

A simplified block diagram of the interface between the vehicleborne guidance system components and the guidance Ground Support Equipment (GSE) is presented in Figure 14.2-1.

14.2 GUIDANCE GSE FUNCTION AND CONTROL

The guidance GSE is provided to facilitate the preparation and confirmation of the launch readiness of the MGS. At the Eastern Test Range guidance GSE is located in the launch area and in the hangar area.

14.2.1 GUIDANCE GSE FUNCTION. The function of the guidance GSE is dependent upon the location and stage of testing.

At the launch area, the guidance GSE may be utilized for either pre-countdown or countdown operations as follows:

Pre-countdown Operations

a. GSE validation.

b. MGS testing and calibration.

c. Guidance support of vehicle tanking tests.

d. Guidance participation in vehicle integrated system tests.

Countdown Operations

a. Final system tests and calibration.

b. Guidance participation in final integrated system tests.

c. Initialization of flight conditions.

d. Participation in final automatic launch sequence.

In the hangar area, the guidance systems are given a post-shipment checkout after delivery from the Convair final assembly plant. Repairs and modifications to the MGS may also be performed there. Hangar laboratory operations primarily involve guidance system testing and calibration.

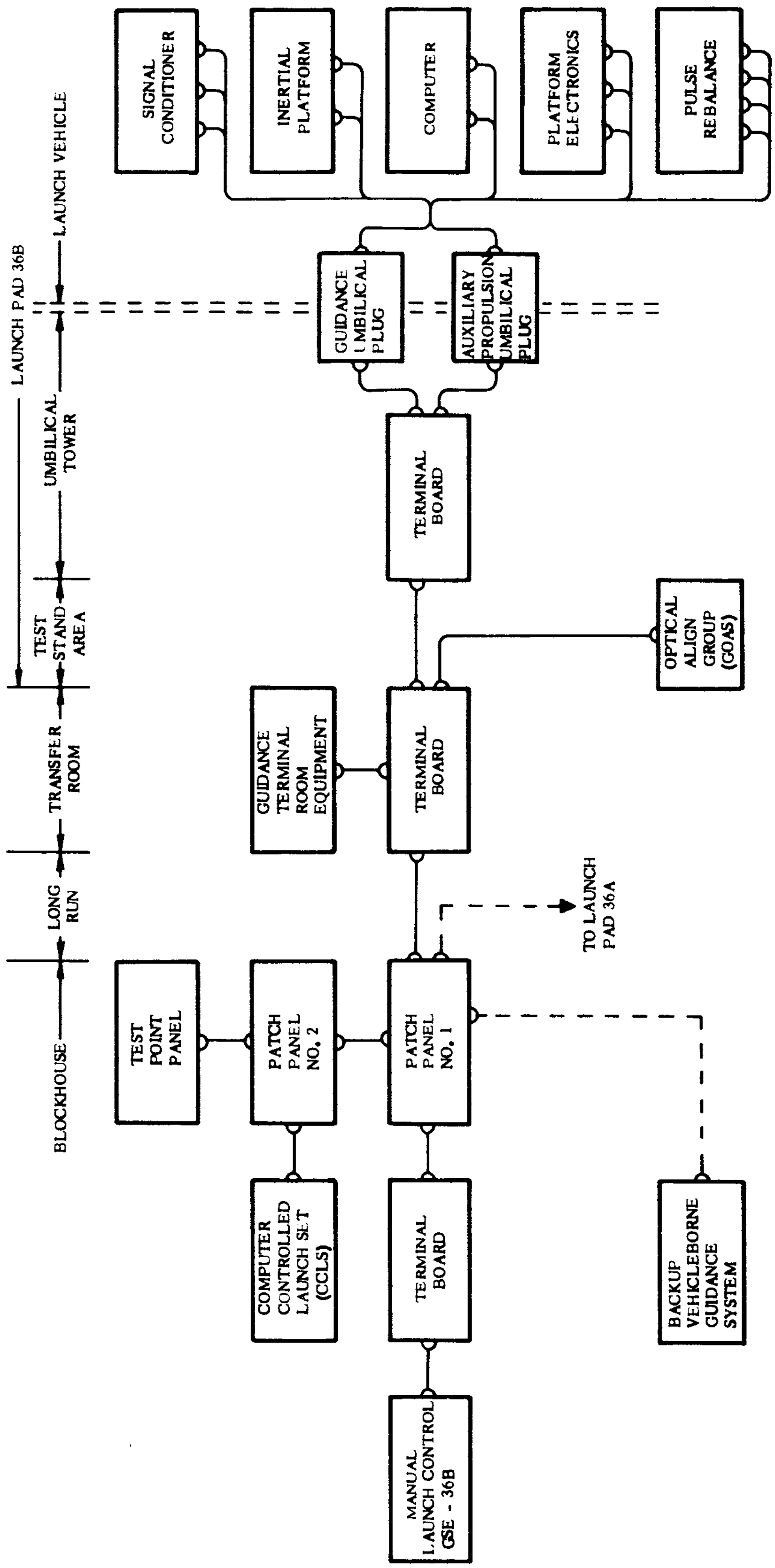


Figure 14.2-1. Block Diagram - Guidance System/GSE Interface

14.2.2 GUIDANCE GSE CONTROL. The guidance GSE at both the launch area and hangar area controls and monitors the same basic functions. However, the technique and scope of guidance function control are not the same at these locations because the detail test objectives are different. This fact is emphasized by the existence of two sets of launch control equipment in the blockhouse at ETR Complex 36. One set is manually controlled, and the other is computer controlled.

Despite the great physical and technical differences between manually controlled launch GSE, computer controlled guidance GSE, and hangar GSE, basic MGS functions are controlled and monitored by the guidance GSE during the various modes. These modes are:

14.2.2.1 Platform Heating and Temperature Control. The fast heat and temperature control amplifier (TCA) circuits of the inertial platform are operated in a proper sequence. Platform temperature status indications are verified during warmup and stabilized operation. Other guidance commands are inhibited until inertial components reach operating temperature.

14.2.2.2 Gimbal Alignment. Gimbal travel limits are verified by slewing gimbals No. 1, 3, and 4 through their angular freedom. The caging indication of gimbal No. 4 is observed. A coarse gimbal alignment is accomplished for each coarse alignment mode. The gimbal-torquing loop dynamic response is evaluated. Gimbal spin alarm circuits are self tested. Gyro stabilization (fine align) and computer program control are initiated by the guidance GSE.

14.2.2.3 Gyro Operation. Spin-motor inhibit and enable functions, before and after warmup, are verified. Calibration consists of updating fixed drifts and mass unbalance along input axes. Gyro torquing loops are also checked for proper sequencing of open and closed loop operation and stable operation during the closed loop portions.

14.2.2.4 Accelerometer Operation. Accelerometer scale factor and bias are updated and the pulse rebalance loop is verified by observing gyro torquing traces during level hold, observing the limit cycle, and counting accelerometer pulses over fixed time intervals.

14.2.2.5 Computer. Testing is performed to verify that the computer-stored program is correct and that the arithmetic unit is functioning properly. Correct computer operation is further verified by checking for generation of specific discretes at correct times.

14.2.2.6 Integration with Other Systems. The correct interface with launch control cabling, telemetry, and landline instrumentation is demonstrated and the effect of specific alignment conditions is observed. Programmed steering and discrete signals from the MGS are observed for correct main engine phasing and amplitude.

14.2.2.7 Launch Control and Alignment. Optical azimuth alignment of the inner gimbal is accomplished using a remote autotheodolite. Appropriate status signals, provided upon entering flight mode, indicate guidance readiness for launch.

14.2.2.8 MGS Electronics. Critical voltages, frequencies, and other parameters are measured to detect departure from specified tolerances that could result in performance degradation or equipment failure.

14.3 MANUAL GUIDANCE LAUNCH CONTROL GROUND SUPPORT EQUIPMENT

Preparation of the MGS for launch requires progression through specific GSE modes of operation which include power control, testing, and launch. All modes are mutually exclusive and are selected primarily by positioning a rotary control switch on the guidance control panel (Figure 14.3-2). Some of the mode control switches allow selection of alternate modes by additional switching.

14.3.1 GSE MODES OF OPERATION. Specific modes of operation of the guidance GSE are described in the following paragraphs.

14.3.1.1 GSE Power Modes. MGS power application, including platform heating and spin motor control, is controlled by switches and interlocks of the guidance control panel.

a. OFF Mode. In this mode, the GSE is not energized.

b. GSE Power On. This mode applies prime ground power (28 vdc, 115 v 400 cps and 115 v 60 cps) through circuit breakers to the GSE. The principal functions accomplished in this mode are as follows:

    1. GSE Check - Manual self-test of the guidance GSE power supplies, and of prime power to the GSE.

    2. Fast Heat - Application of fast heat to the gyro and accelerometer fast warmup heaters until a temperature of 155° F is reached. Fast heat is then disabled and the TCA is enabled, controlling platform heating until its temperature is stabilized at 180° F. Fast heat requires approximately 45 minutes and total heating time to a stabilized temperature is about one hour. Visual indication of stable temperature attainment is provided.

    3. Spin Motor Inhibit - The inertial components are not energized until they are brought up to operating temperature. Application of power to the spin motors is interlocked with the fast heat circuit.

    4. Enable Computer - Power is made available to the computer for warmup and standby, but a separate manually operated switch is provided to initiate drum run up.

c. MGS Power On. Before entering this mode, it is necessary that the vehicle inverter be on, MGS platform temperature be stabilized (temperature monitors illuminated) and GSE checks be complete. Specific functions performed in this mode are as follows:

1. Power Application - Primary power (400 cps) is automatically applied to GSE alignment circuits from the vehicleborne inverter.

2. MGS Power Supplies - The MGS power supplies are enabled automatically and the output voltages are checked.

3. Spin Motors Enable - The gyro spin motors are energized from the vehicle-borne inverter power by actuating a switch on the guidance control panel.

4. Enable Computer - Prime power is made available to the computer from the MGS coupler, but a separate switch must be actuated to initiate drum run up.

5. MGS Functional Tests - Tests performed prior to Align Modes to assure the functional capability of the MGS are as follows:

   a) Gimbal Drive Test - Conducted to verify servo loop operation and ascertain that no gimbal interference exists.

   b) Gimbal Response Test - Gimbals are driven to a predetermined orientation and the dynamic response of the four gimbal stabilization loops checked for step inputs that are applied simultaneously.

   c) Coarse Alignment - Gimbals 1, 3 and 4 may be coarse aligned to a desired angular orientation. The angle is selected manually and the gimbals orient to this angle in closed loop operation.

   d) Resolver Alignment Monitor - The resolver in the Alignment Reference Unit can be aligned with the platform gimbal resolvers to monitor the position of the platform gimbals.

14.3.1.2 Computer Test Mode. This mode of operation checks the computer permanent storage (program) and arithmetic unit. After drum run-up, a diagnostic routine is performed. The test is initiated by a Mode Set signal, and after 72 seconds a Memory Sum OK is issued followed by all of the discretes.

14.3.1.3 Align Modes. There are seven modes in which the platform may be aligned to a predetermined orientation. Align modes 1 through 6 are used to determine and verify gyro drift rates and accelerometer bias and scale factors. The platform is oriented so as to subject the three accelerometers to local gravity force in each direction, and the three gyros are subjected to local earth spin rate.

Final Align Mode is used to orient the inertial platform gimbals to the launch position. The azimuth gyro is coupled and slaved to the pre-pointed optical autotheodolite. The autotheodolite is pointed (surveyed) as part of the precountdown operations, and checked as part of the system calibration operation during countdown.

14.3.1.4 Integrated Test Mode. This mode of operation is a guidance - flight control compatibility check. Vertical accelerometer data cause the computers to emit the integrated test program and discretes from its permanent storage. These computer output signals result in steering signals to the resolver chain for eventual engine movement to correct vehicle position and velocity. This test mode is used during MGS checkout, Flight Control Integrated Test, and the Composite Readiness test.

14.3.1.5 Remote Load and Read Mode. This mode allows an operator to check and update the scaling and compensation factors stored in the guidance computer. The R L & R mode may be entered when the guidance Mode Select switch is in any align mode or the Computer Test Mode.

14.3.1.6 Launch-On-Time Modes. The Launch-On-Time (LOT) function uses two modes; an LOT Initiate Mode in which the guidance computer program timing is synchronized with sidereal time, and an LOT Backup Mode. The LOT Backup Mode allows a second chance at synchronizing program timing in the event the first effort fails. LOT backup occurs automatically if the computer fails to issue a Mode Accept signal at LOT initiate. LOT modes are entered from the final align mode.

14.3.1.7 Flight Mode. The FLIGHT mode initiates the flight program. Flight mode is enabled by the FLIGHT position of the Mode Select switch on the Guidance Control Panel, however, a FLIGHT signal must be received from the test conductor panel (see Figure 12.2-1) in order to activate this mode. Either simulated or actual flight can be accomplished in this mode.

14.3.1.8 Mode Control. Entry into the three power control modes is accomplished by selector switch positioning. All of the other modes may be considered MGS or computer modes since they depend upon issuance of computer discretes for mode entry. The MGS modes, except for Flight Mode, all require Mode Select switch positioning and operator actuation of the Mode Set pushbutton switch. Subsequently, the computer issues the Mode Accept discrete and later, the Mode Complete discrete. Flight Mode does not yield a Mode Complete signal.

The computer mode code circuitry controls the selection of operational modes of the computer and transfers this selection capability to the Remote Load and Read assembly.

The Mode Select switch generates a ten-bit binary code in each of ten different switch positions. Three additional codes are generated by the following logic input signals; RL & R select, LOT initiate, and LOT initiate backup.

Computer lines M0, M1, M2, M3, and M4 are set in the "1" or "0" condition corresponding to the presence or absence of a +35.5 volt level on each line. The complement of the above codes is set on lines $\overline{M0}$, $\overline{M1}$, $\overline{M2}$, $\overline{M3}$, and $\overline{M4}$ respectively. The binary code for the operational modes and the logic input signals are presented in Table 14.3-1.

14.3.1.9 <u>Guidance Ready Ladder.</u> MGS launch readiness is contingent upon successful completion of a series of guidance functions:

a. ACQUISITION (optical alignment complete)

b. LEVEL ALIGN COMPLETE (inertial platform leveled and stabilized)

c. GIMBAL "4" CAGED

d. COMPUTER "GO" (navigation computer ready)

The successful accomplishment and continuous retention of these four conditions yields a GUIDANCE READY signal. The final commit sequence requires both GUIDANCE READY and FLIGHT ACCEPTANCE indications for successful initiation of the flight program to enable the Engine Start sequence.

14.3.2 MANUAL LAUNCH CONTROL GSE COMPONENTS. The major components of the guidance manually operated launch control GSE are located in the blockhouse, transfer room, and Guidance Optical Alignment Shelter (GOAS). In addition, provisions exist on the service tower to connect a validation unit.

14.3.2.1 <u>Blockhouse Guidance Launch Control GSE.</u> The guidance launch control equipment group for Launch Complex 36B consists of five bays of government furnished test and control equipment (see Figure 14.3-1). A cursory description of each bay of equipment is contained in the following paragraphs. For a detailed description of these components, refer to the "Operation and Maintenance Manual for Centaur Inertial Guidance System DYG8016, Volume III, Ground Support Equipment", Honeywell document number 61781-M-3.

a. Bay 1, Remote Load and Read Test Set. The Remote Load and Read (RL & R) test set provides a basic capability of reading and filling computer "j" and "d" value parameters, located in temporary storage such as the launch control area, after the computer has been installed in the guidance compartment of the Centaur vehicle. The test set is a single-bay rack assembly consisting of the following:

   1. Remote Load and Read control panel. This panel contains manual program controls and a visual indicator arranged in the computer word format. This panel is the primary control for filling and interrogating the Centaur guidance computer.

TABLE 14.3-1. Mode Code Index

MODE SELECT SWITCH POSITION	MODE CODE NO.	MODE CODE LINE STATUS									
		M4	M3	M2	M1	M0	$\overline{M4}$	$\overline{M3}$	$\overline{M2}$	$\overline{M1}$	$\overline{M0}$
OFF		0	0	0	0	0	0	0	0	0	0
GSE POWER ON		0	0	0	0	0	0	0	0	0	0
MGS POWER ON		0	0	0	0	0	0	0	0	0	0
COMPUTER TEST	28	1	1	1	0	0	0	0	0	1	1
ALIGN 1	1	0	0	0	0	1	1	1	1	1	0
ALIGN 2	2	0	0	0	1	0	1	1	1	0	1
ALIGN 3	3	0	0	0	1	1	1	1	1	0	0
ALIGN 4	4	0	0	1	0	0	1	1	0	1	1
ALIGN 5	5	0	0	1	0	1	1	1	0	1	0
ALIGN 6	6	0	0	1	1	0	1	1	0	0	1
INTEGRATED TEST	30	1	1	1	1	0	0	0	0	0	1
FINAL ALIGN	14	0	1	1	1	0	1	0	0	0	1
FLIGHT	29	1	1	1	0	1	0	0	0	1	0
(Additional modes not necessarily functions of Mode Select Switch)											
		M4	M3	M2	M1	M0	$\overline{M4}$	$\overline{M3}$	$\overline{M2}$	$\overline{M1}$	$\overline{M0}$
RL & R	27	1	1	0	1	1	0	0	1	0	0
LOT INITIATE	16	1	0	0	0	0	0	1	1	1	1
LOT INITIATE BACKUP	24	1	1	0	0	0	0	0	1	1	1

2. Folded Paper Printer. This printer is selectively permitted to print a permanent record of outputs from the computer. This printer is a transistorized electromechanical device that provides a printed record of digital information.

3. Tape Reader and Tape Reader Remote Control. The tape reader permits rapid filling and interrogation of the temporary storage tracks of the computer main memory. This is a photoelectric tape reader, designed for reading an eight channel punched tape.

4. Power Supply Assembly. This unit provides +28 vdc, -18 vdc, and +12 vdc to the remote load and read control panel. The power supply consists of three independent power modules (transistorized) and operate from a 105 to 115 volts a.c., 60 cycle facility power source.

5. Remote Load and Read Power Control. A circuit breaker is provided to protect the "j" and "d" value equipment from heavy overloads on the incoming 115 volt, 60 cps power line.

The RL & R equipment rack measures 72x24x24 inches and weighs approximately 300 pounds. Detailed information concerning the RL & R equipment maintenance and operation may be found in the "Operation and Maintenance Manual for Centaur Inertial Guidance System, Volume IV, Remote Load and Read Equipment", Honeywell Document No. 6178-M-4.

b. Bays 2 and 3, Blockhouse Rack Assemblies. These two bays of equipment are used in the prelaunch alignment and checkout of the vehicle guidance set. They contain the following equipment:

1. Oscilloscope. Used to examine digital or analog signals from the inertial guidance system and to provide for phase shift measuring and other general purpose use.

2. Bidirectional Counter. A decimal readout counter used in general counting operation.

3. Guidance Control Panel. This unit provides primary control and monitoring of the guidance system. It provides operating control of the MGS and GSE during prelaunch checkout of the inertial navigation system. The control panel is shown in Figure 14.3-2. A functional description of the panel controls and indicators is presented in Table 14.3-2.

4. Writing Desk. This is a pullout drawer which provides a writing surface.

5. IGS Power Control. This control provides prime MGS and GSE power control and overload protection.

6. Digital Voltmeter. Consists of a self contained A/D converter power supply, and digital readout.

7. Alignment Reference Unit. Provides the angular reference used to coarse align the inertial platform gimbals.

8. DVM Input Control. Selects the input signals to be routed to the digital voltmeter.

9. Counter Input Control. Selects the input signals to be routed to the counter.

10. Remote Optical Control Panel (ROCP). Used in optical azimuth alignment of the inertial platform. The ROCP is the blockhouse control unit for the Optical Alignment Control Group (OACG). All controls necessary for OACG operation as well as indicators for status verification are contained on this panel.

11. Accelerometer Limit Cycle Monitor (Ref. GD/C 55-49182). Continuously monitors the positive and negative pulse trains from each of the vehicle systems' accelerometers and provides automatic readout of go, no-go status.

Each of the above equipment racks measures 72×24×24 inches and weighs approximately 300 pounds. Detailed information concerning the ROCP may be found in the "Operation and Maintenance Manual for Centaur Inertial Guidance System, Volume V, Optical Alignment Control Group," Honeywell Document No. 6178-M-5.

c. Bay 4, Launch-on-Time (LOT). The LOT rack contains a Launch-on-Time Decoder panel, a Writing Desk, and a Power Supply panel. The LOT decoder monitors the ETR time signal, decodes it, and transmits a precise time signal to the computer. The computer uses the signal to modify flight equations.

The rack measures 72x24x24 inches and weighs approximately 300 pounds.

d. Bay 5, Recorder Rack Assembly. The recorder rack contains a Sanborn Series 850 eight-channel recorder with associated dc preamplifiers. A recorder input control provides a means of selecting signals to be routed to the recorder.

A blower in the bottom of the rack provides cooling air.

This assembly measures 72x24x24 inches and weighs approximately 500 pounds.

14.3.2.2 Transfer Room GSE. The transfer room equipment portion of the guidance GSE consists of a single bay, 6 foot equipment rack containing isolation amplifiers and a power supply. The equipment rack measures 71.5x24x23.9 inches in size.

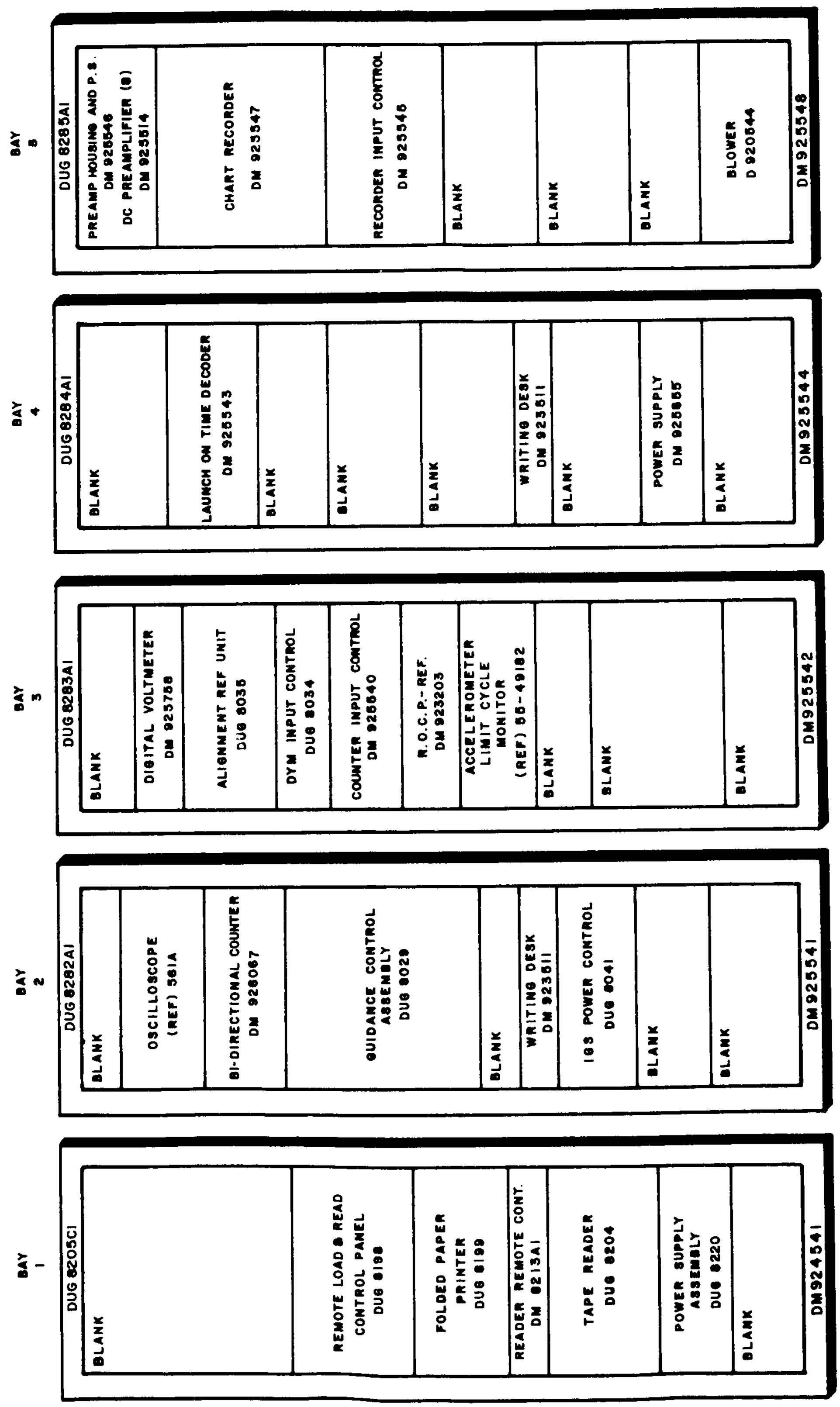


Figure 14.3-1. Vehicle Guidance Launch Control Equipment Group

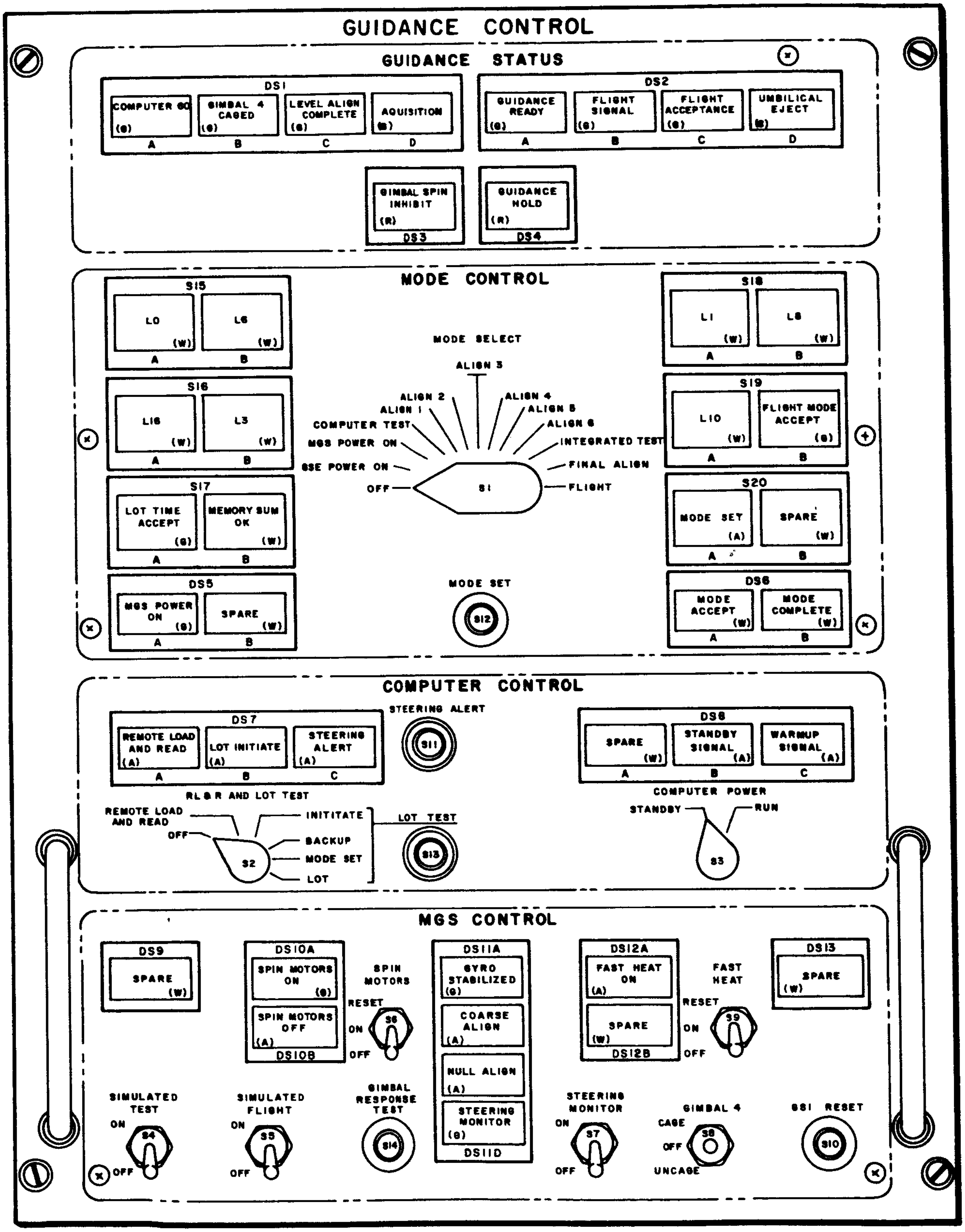


Figure 14.3-2. Guidance Control Assembly

Table 14.3-2. Guidance Control Assembly Front Panel Controls and Indicators

Control or Indicator	Function
Mode Select rotary switch, S1	Connects power to circuits as indicated for test and operation.
RL&R and LOT TEST rotary switch, S2	In RL&R position provides an RL&R mode code on the GCP ten bit binary encoder to computer. In LOT TEST position provides signals as indicated to GCP.
COMPUTER POWER rotary switch, S3	Provides standby ground to RL&R and power to computer drum and write amplifiers.
SIMULATED TEST switch, S4	Applies a +28 volts dc enabling voltage to simulation switches.
SIMULATED FLIGHT switch, S5	Provides simulated flight sequal when conducting local or simulated flight tests.
SPIN MOTORS switch, S6	Supplies excitation to output control relay in the spin motor power supply.
STEERING MONITOR switch, S7	Removes voltage from MGS resolver align relays in ON position.
GIMBAL 4 switch, S8	Supplies a ground and a +12 volt dc signal to gimbal 4 caging relay in the platform electronics.
FAST HEAT switch, S9	Provides control of fast heat current to platform heaters.
GSI RESET pushbutton, S10	Unlatches circuits energized by inhibiting action.
STEERING ALERT pushbutton, S11	Provides a signal to the computer to command exit from idle routine.
MODE SET pushbutton, S12	Applies a +28 volt dc signal to the mode set signal line.
LOT TEST pushbutton, S13	Simulates LOT signals.

Table 14.3-2. Guidance Control Assembly Front Panel Controls and Indicators, Cont

Control or Indicator	Function
GIMBAL RESPONSE TEST switch, S14	Provides a one-second +28 volt dc signal to MGS response test relay.
LO pushbutton indicator, S15A	Indicates receipt of vernier engine cutoff discrete. Press to remove discrete.
L6 pushbutton indicator, S15B	Indicates receipt of sustainer engine cutoff discrete. Press to remove discrete.
L16 pushbutton indicator, S16A	Indicates receipt of main engine cutoff discrete. Press to remove discrete.
L3 pushbutton indicator, S16B	Indicates receipt of booster engine cutoff discrete. Press to remove discrete.
LOT TIME ACCEPT pushbutton indicator, S17A	Indicates receipt of lot time accept discrete. Press to remove discrete.
MEMORY SUM OK pushbutton indicator, S17B	Indicates receipt of memory sum OK discrete. Press to remove discrete.
L1 pushbutton indicator, S18A	Indicates receipt of main engine start discrete. Press to remove discrete.
L8 pushbutton indicator, S18B	Indicates receipt of separate spacecraft discrete. Press to remove discrete.
L10 pushbutton indicator, S19A	Indicates receipt of reorient discrete. Press to remove discrete.
FLIGHT MODE ACCEPT pushbutton indicator, S19B	Indicates receipt of flight mode accept discrete. Press to remove discrete.
MODE SET pushbutton indicator, S20A	Indicates receipt of mode set discrete. Press to remove discrete should a nonfunctional computer fail to issue a discrete.
SPARE pushbutton indicator, S20B	
COMPUTER GO indicator, DS1A	Indicates receipt of computer go discrete.

Table 14.3-2. Guidance Control Assembly Front Panel Controls and Indicators, Cont

Control or Indicator	Function
GIMBAL 4 CAGED indicator DS1B	Indicates receipt of gimbal 4 caged discrete.
LEVEL ALIGN COMPLETE indicator DS1C	Indicates receipt of mode complete discrete while in final align mode.
ACQUISITION indicator, DS1D	Indicates platform Porro prism has been acquired by the autotheodolite.
GUIDANCE READY indicator, DS2A	Illuminated if the gimbal 4 caged computer ready, and acquisition conditions are present and not gyro stabilized condition is not present.
FLIGHT SIGNAL indicator, DS2B	Indicates receipt of flight signal discrete.
FLIGHT ACCEPTANCE indicator, DS2C	Illuminates if flight conditions are present.
UMBILICAL EJECT indicator, DS2D	Indicates receipt of umbilical eject discrete.
GIMBAL SPIN INHIBIT indicator, DS3	Illuminated whenever a platform gimbal tends to spin.
GUIDANCE HOLD indicator, DS4	Indicates absence of guidance ready signal.
MGS POWER ON indicator, DS5A	Indicates receipt of power on signal.
SPARE indicator, DS5B	
MODE ACCEPT indicator, DS6A	Indicates receipt of mode accept discrete.
MODE COMPLETE indicator, DS6B	Indicates receipt of mode complete discrete.
REMOTE LOAD AND READ indicator, DS7A	Indicates receipt of RL&R signal with computer switch in REMOTE LOAD AND READ position and mode accept condition present.
LOT INITIATE indicator, DS7B	Indicates function of LOT control circuits.

Table 14.3-2. Guidance Control Assembly Front Panel Controls and Indicators, Cont

Control or Indicator	Function
STEERING ALERT indicator, DS7C	Indicates LOT steering alert signal is present to computer provided control has not been transferred to RL&R equipment.
SPARE indicator, DS8A	
STANDBY SIGNAL indicator, DS8B	Indicates computer standby condition.
WARMUP SIGNAL indicator, DS8C	Indicates computer warmup condition.
SPARE indicator, DS9	
SPIN MOTORS ON indicator, DS10A	Illuminated when signal is received from spin motor monitor circuit.
SPIN MOTORS OFF indicator DS10B	Illuminated when spin motors on circuit is de-energized and spin motor switch is in the OFF position.
GYRO STABILIZED indicator, DS11A	Illuminated in gyro stabilized mode and COARSE ALIGN indicator not illuminated.
COARSE ALIGN indicator, DS11B	Illuminated in coarse align mode and GYRO STABILIZED indicator not illuminated.
NULL ALIGN indicator, DS11C	Illuminated at MGS power on until spin motors are on for 30 seconds or by a loss of spin motor power.
STEERING MOTOR indicator, DS11D	Illuminated when resolver align relay outputs signal is 0 volts dc.
FAST HEAT ON indicator, DS12A	Indicates fast heat on condition.
SPARE indicator, DS12B	
SPARE indicator, DS13	

a. Amplifier Chassis Assembly. The amplifier chassis assembly consists of eleven plug-in amplifier modules which are of three types; an a.c. coupled inverting amplifier, a d.c. coupled non-inverting linear pulse amplifier, and a switching pulse restoring amplifier. The chassis measures 10.5x19x 18.19 inches in size.

b. Power Supply. The power supply chassis consists of two identical 50 vdc power supplies, a power control relay, and three line filters. This chassis measures 10.5x19x18.19 inches in size.

14.3.2.3 Guidance Optical Alignment Shelter (GOAS). The GOAS houses the Optical Alignment Control Group (OACG) which provides an automatic optical azimuth alignment capability to existing Centaur guidance GSE. The OACG is used in conjunction with the Centaur Inertial Guidance System and its associated GSE to accurately establish the launch azimuth of the vehicle platform U accelerometer input axis (see Figure 14.3-3). Figure 14.3-4 is a block diagram showing the components which make up the OACG and the major signal flow between the components. A block diagram of the OACG site installation is presented in Figure 14.3-5.

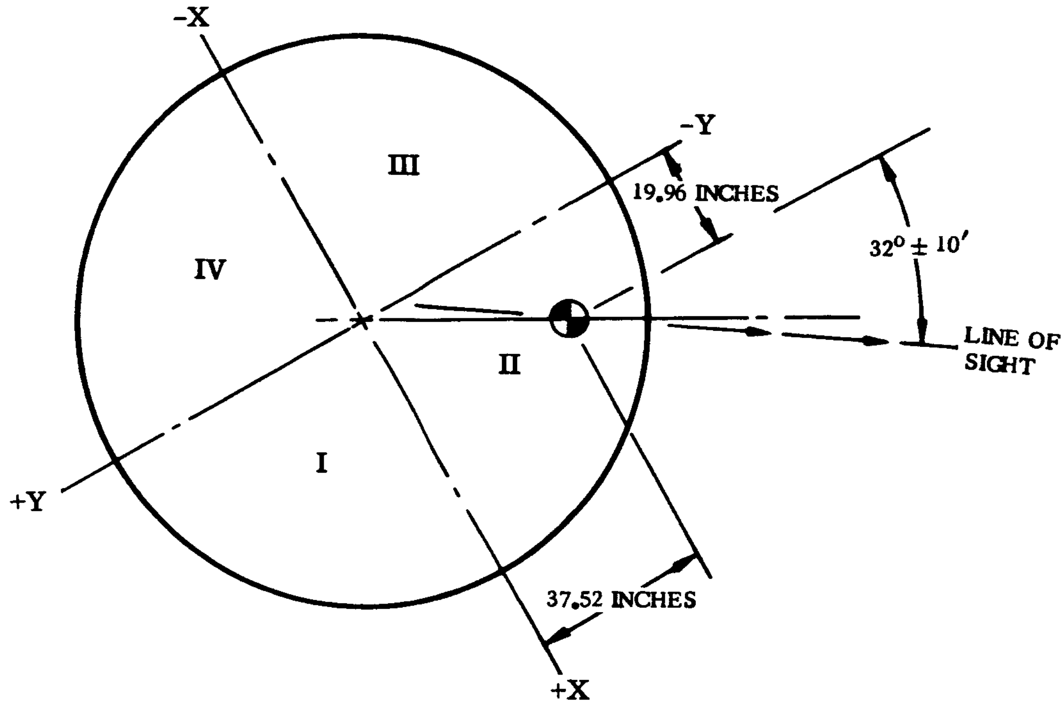
The OACG consists of the following major assemblies:

a. Guidance Optical Alignment Shelter Console. This assembly is a single bay rack assembly, illustrated in Figure 14.3-6. Mounting and interface connections for the OACG panels located in the GOAS are provided for in this rack. These panels are described in the following paragraphs.

   1. Autotheodolite Control Panel. This panel provides the monitoring indicators and controls for the autotheodolite assembly. Both azimuth error signals and acquisition signal are amplified and demodulated in this unit.

   2. Local Optical Control Panel (LOCP). This panel provides both operating and test controls and the logic switching for the OACG. The LOCP contains the control loop operational amplifier and associated power supplies, has the necessary electronics required to operate in conjunction with the autotheodolite and the platform manual torquing signals, and provides test and calibration functions. Lamp indicators display OACG operating status. Switches which are enabled from the remote optical control panel in the blockhouse, permit power control and normal operation of the OACG.

   3. Remote Torquing Control. This is a hand-held device which is plugged into a jack on the LOCP and is designed to be used at the autotheodolite location. It contains a DIRECTION switch and a RATE control which are identical in function to the controls on the LOCP and the ROCP. The LOCP rate and direction controls are disabled when the remote torquing control is plugged in.



Plan View

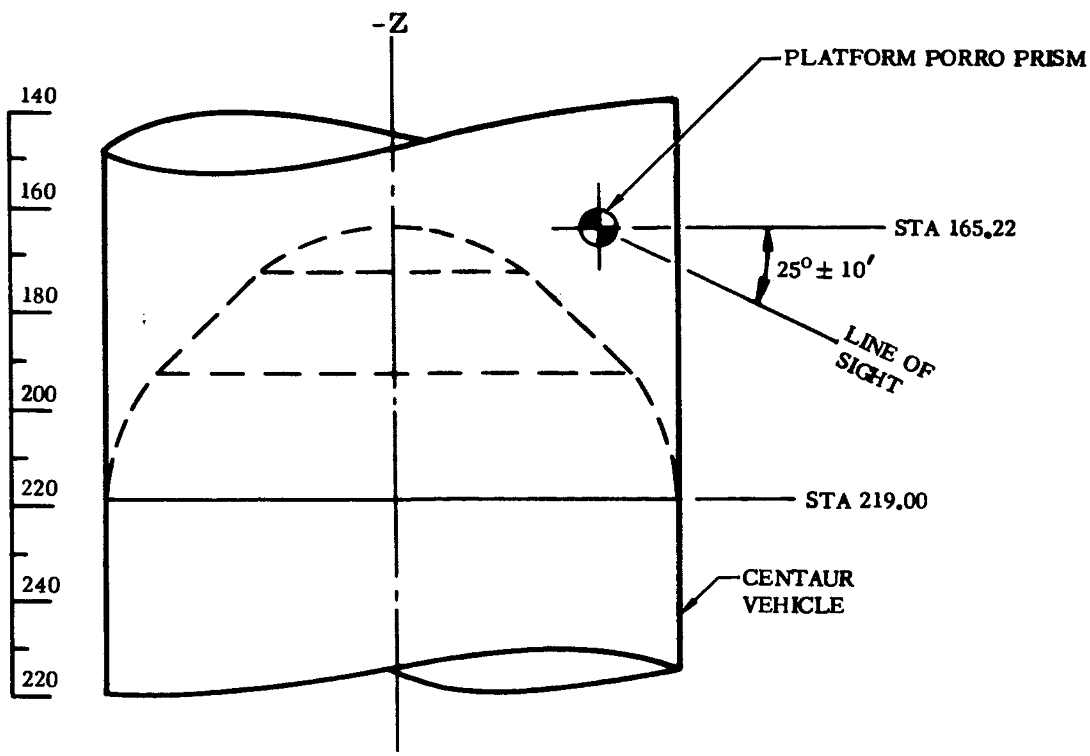


Figure 14.3-3. Optical Line of Sight, Guidance Platform Azimuth Alignment

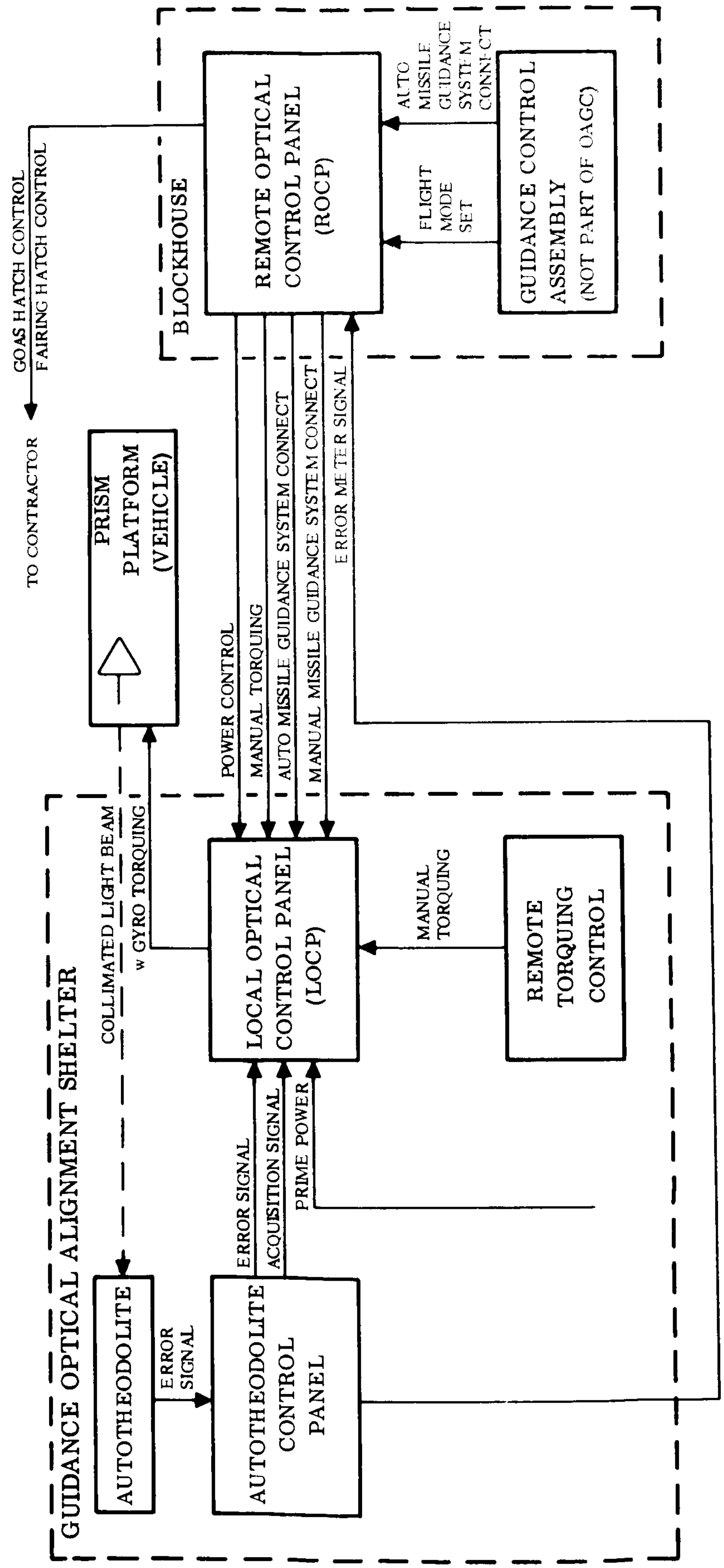


Figure 14.3-4. Optical Alignment Control Group Block Diagram

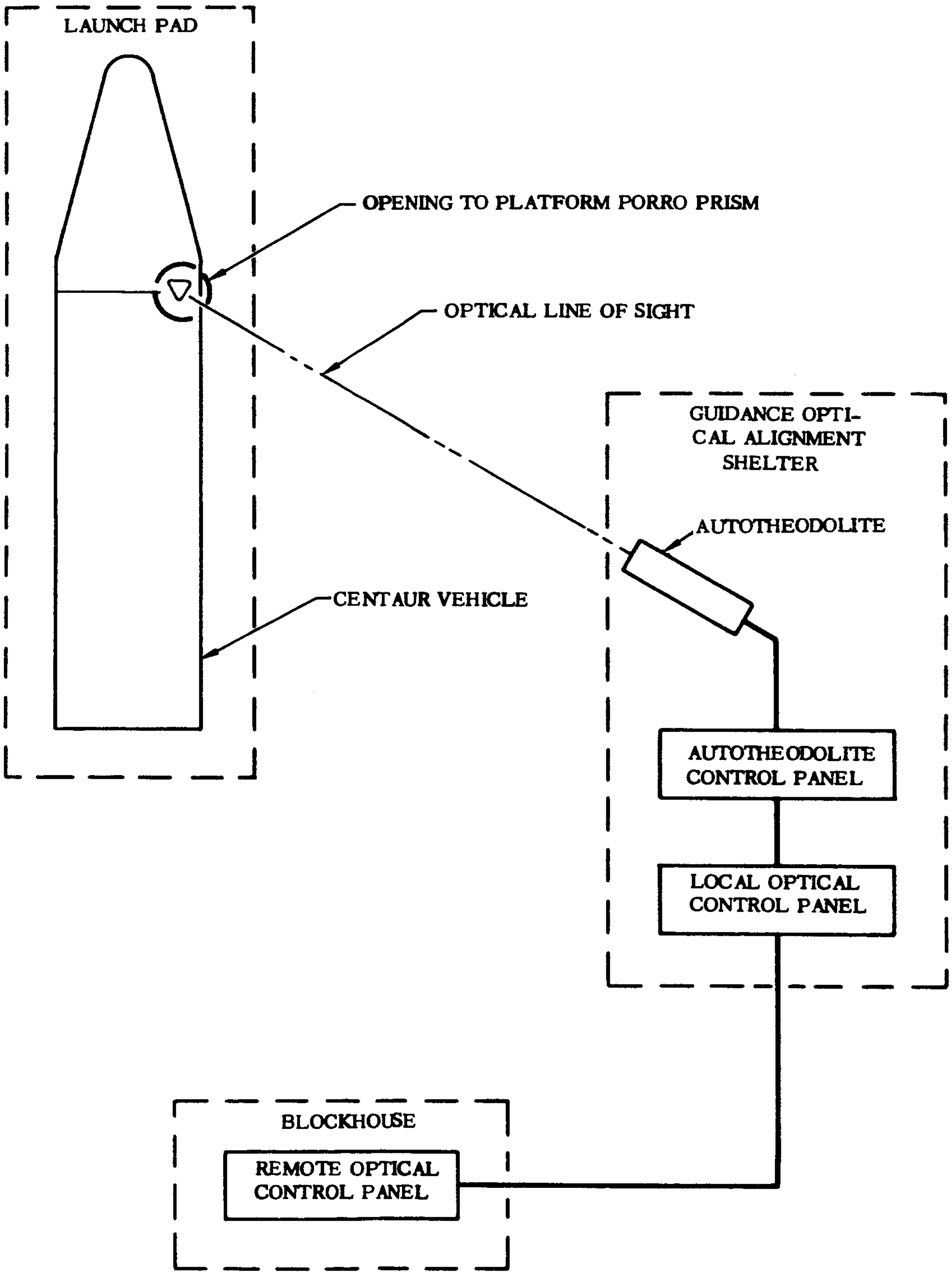


Figure 14.3-5. Optical Alignment Control Group Site Installation, Block Diagram

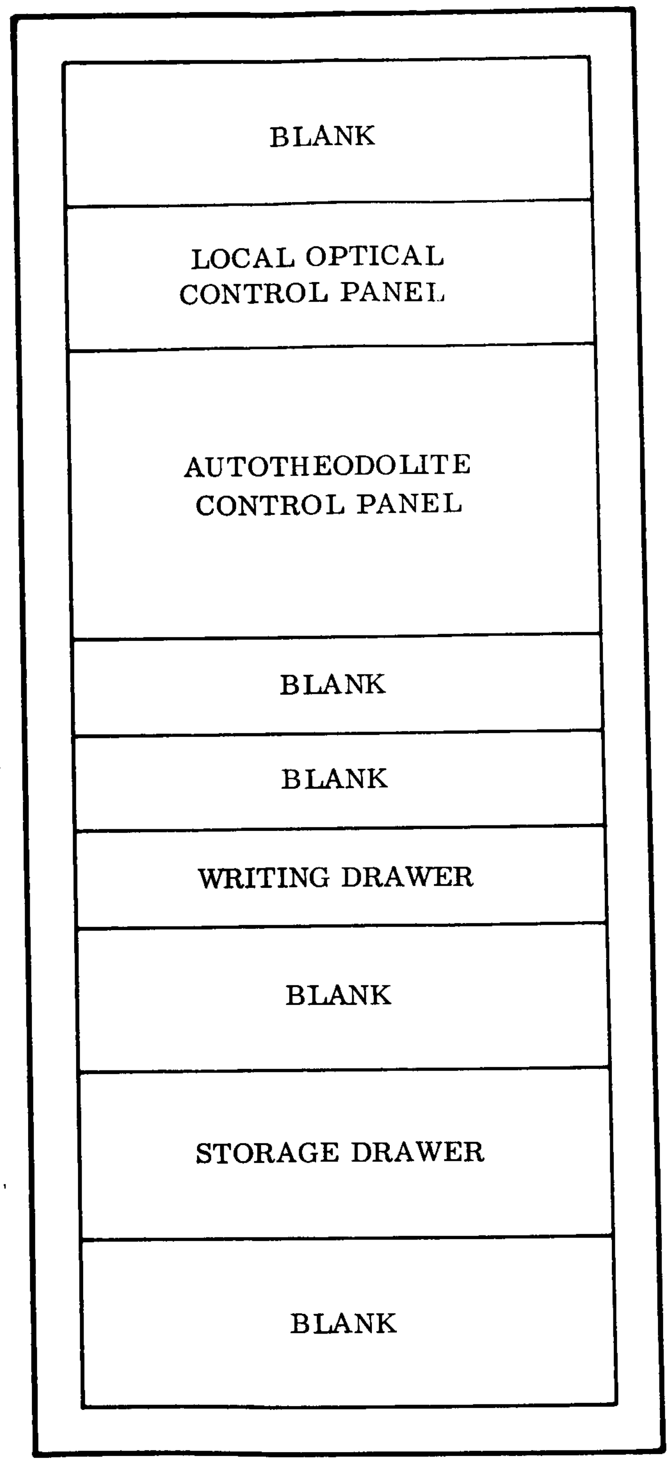


Figure 14.3-6. Guidance Optical Alignment Shelter Console

b. Blockhouse Rack Assembly. The only OACG component located in the blockhouse is the Remote Optical Control Panel (ROCP) mounted in Bay 3 of the blockhouse rack assembly (see Figure 14.3-1). This panel is the master control unit for the OACG. All controls necessary for OACG operation as well as indicators for status varification are contained on this panel. Manual platform torquing controls and an autotheodolite error signal meter are provided to enable optical acquisition of the platform Porro prism. Controls are provided for transferring operating control of the OACG to the LOCP located in the GOAS.

c. Autotheodolite Assembly. The Autotheodolite Assembly is manufactured by the Electro-Optical Division of the Perkin-Elmer Corporation. It is illustrated in Figure 14.3-7. The assembly is located in the GOAS and consists of the following major components:

1. Mounting Fixture. The mounting fixture consists of a base plate, a base mount, and a slide assembly. The slide assembly moves on precision rails which are a part of the base mount. The assembly provides for lateral translation of ±10 inches from the nominal autotheodolite line of sight, an elevation adjustment of ±5 degrees from a nominal 25 degree elevation angle, and an azimuth adjustment of ±2 degrees from the nominal line of sight azimuth.

2. Autocollimator. This component provides the electro-optical system for sensing the vehicle platform Porro prism azimuth misalignment. A detailed functional description of this component may be found in the tion and Maintenance Manual for Centaur Inertial Guidance System, Volume V, Optical Alignment Control Group", Honeywell Document No. 6178-M-5.

3. Reference Prism Assembly. The reference prism assembly includes a Porro prism, a prism mount, and a mounting pedestal (see Figure 14.3.7). The prism is installed on the site mounting pier center line in front of the autotheodolite and provides the reference for azimuth alignment of the autotheodolite. A survey theodolite, which has optical access to the site reference bench marks and is used to transfer the reference line of sight established by the bench marks to the reference prism, is mounted on the pier center line but to the rear of the autotheodolite.

The reference prism is mirrored on one end to allow leveling of the prism using an auxiliary survey theodolite. Leveling and azimuth adjustments are provided on the base plate.

d. Power Requirements. The OACG requires the following power input:

28 ± 2 vdc, 140 watts.
115 ±5% volts 400 ±2 cps a.c., 75 volt-amps.
115 ±5% volts 60 ±2 cps a.c., 1, 265 watts.

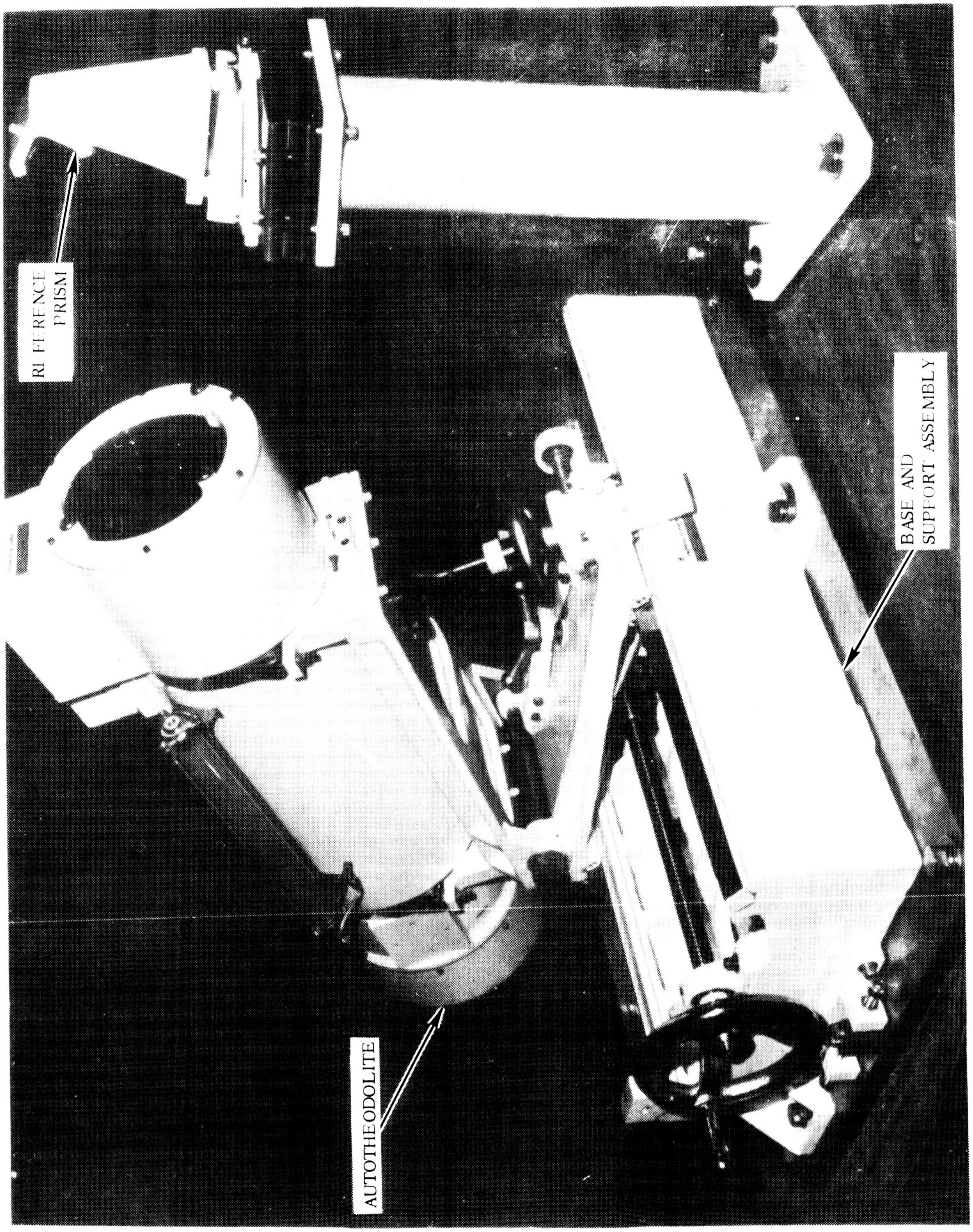


Figure 14.3-7. Autotheodolite Assembly

14.3.2.4 Service Tower. Power outlets are provided on the service tower to accomodate the use of a missile guidance system simulator (MGSS) for validation of the launch site GSE. The MGS simulator is normally stored in Hangar "H" at the ETR when not in use. The MGS simulator is described in Paragraph 14.6.1.

14.4 COMPUTER CONTROLLED LAUNCH SET

A Computer Controlled Launch Set (CCLS) is located in the lower level of the ETR Complex 36 blockhouse. The CCLS consists of approximately 23 racks of equipment. Switching (patch panel) is provided to allow use of either launch pad 36A or 36B (see Figure 14.2-1). The CCLS may be used in lieu of the manually operated launch control GSE.

14.4.1 CCLS FUNCTION AND CONTROL. The CCLS automatically tests and evaluates the launch readiness of the Centaur guidance system. The CCLS is capable of performing all of the functions of the manually operated guidance GSE. In addition, the CCLS controls operations in an automatic sequence in accordance with a predetermined stored program, and operator intervention is required only to initiate variations in test routine or in the event of MGS malfunction. The program that controls the checkout and/or launch preparation of the guidance system is composed of two parts; an executive program routine, which organizes and controls sub-programs, and a group of sub-programs or coded routines that perform detailed control of the guidance system.

The effectiveness of the computer in an automatic control function is measured by the flexibility and ease of preparing the program. For this reason, many programming languages and techniques have been developed to simplify the programming task. Operational programs for the CCLS employ both REAL TIME FORTRAN II and SYMBOL for maximum efficiency in control of the guidance system.

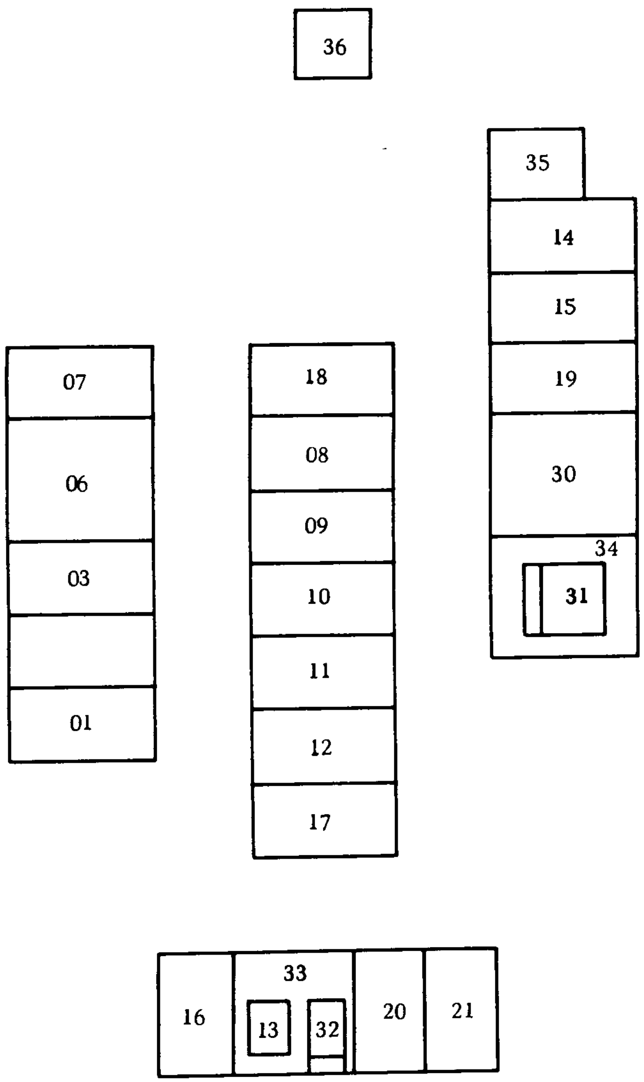
14.4.2 CCLS COMPONENTS. The CCLS, designated as GD/C 55-49200, is comprised of a digital computer with peripheral and auxiliary equipment for input/output, display, control, and interface with the launch site. The major equipment groups of the CCLS are as follows:

a. The ATE-2230 Automatic Test Set, Supplied by Scientific Data Systems (SDS).

b. The DD-10 Display System supplied by Data Displays, Inc (DDI).

c. Auxiliary electronics to interface the ATE-2230 with the guidance system.

A plan view of the equipment arrangement in the blockhouse is shown in Figure 14.4-1. A block diagram showing CCLS component interfaces is presented in Figure 14.4-2.



No.	Item	Mfd By
01	DISC COUPLERS	SDS
02	DIS FILE	SDS
03	BUFFERS, INTERRUPTS	SDS
06	MEMORY	SDS
07	MEMORY POWER SUPPLIES	SDS
08	CONTROL, TAPE READ	SDS
09	MAGNETIC TAPE	SDS
10	EOM, SKS, PIN, POT	SDS
11	ANALOG-TO-DIGITAL, MULTIPLE	SDS
12	DIGITAL-TO-ANALOG	SDS
13	CARD READER	SDS
14	PATCH BOARD, SCOPE	GDC
15	RELAYS, FILTERS	GDC
16	TELETYPE	SDS
17	DISC FILE	SDS
18	AUXILIARY (UNASSIGNED)	GDC
19	DELTA V, PIN-POT EXTEND	GDC
20	RENTED MAGNETIC TAPE	SDS
21	RENTED MAGNETIC TAPE	SDS
30	DISPLAY CONTROL UNIT	DDI
31	DISPLAY, OBSERVERS	DDI
33	TABLE, DISPLAY, CARD READER	GDC
34	TABLE, OBSERVER DISPLAY	GDC
35	PATCH RACK	GDC
36	INVERTRON (BEHLMAN)	

NOTES:

1. SDS is Scientific Data Systems
2. GDC is General Dynamics, Convair
3. DDI is Data Displays, Inc., Division of Control Data Systems
4. Behlman is Behlman-Invar Electronics, Inc.

Figure 14.4-1. Plan View of CCLS Equipment Arrangement, Complex 36 Blockhouse

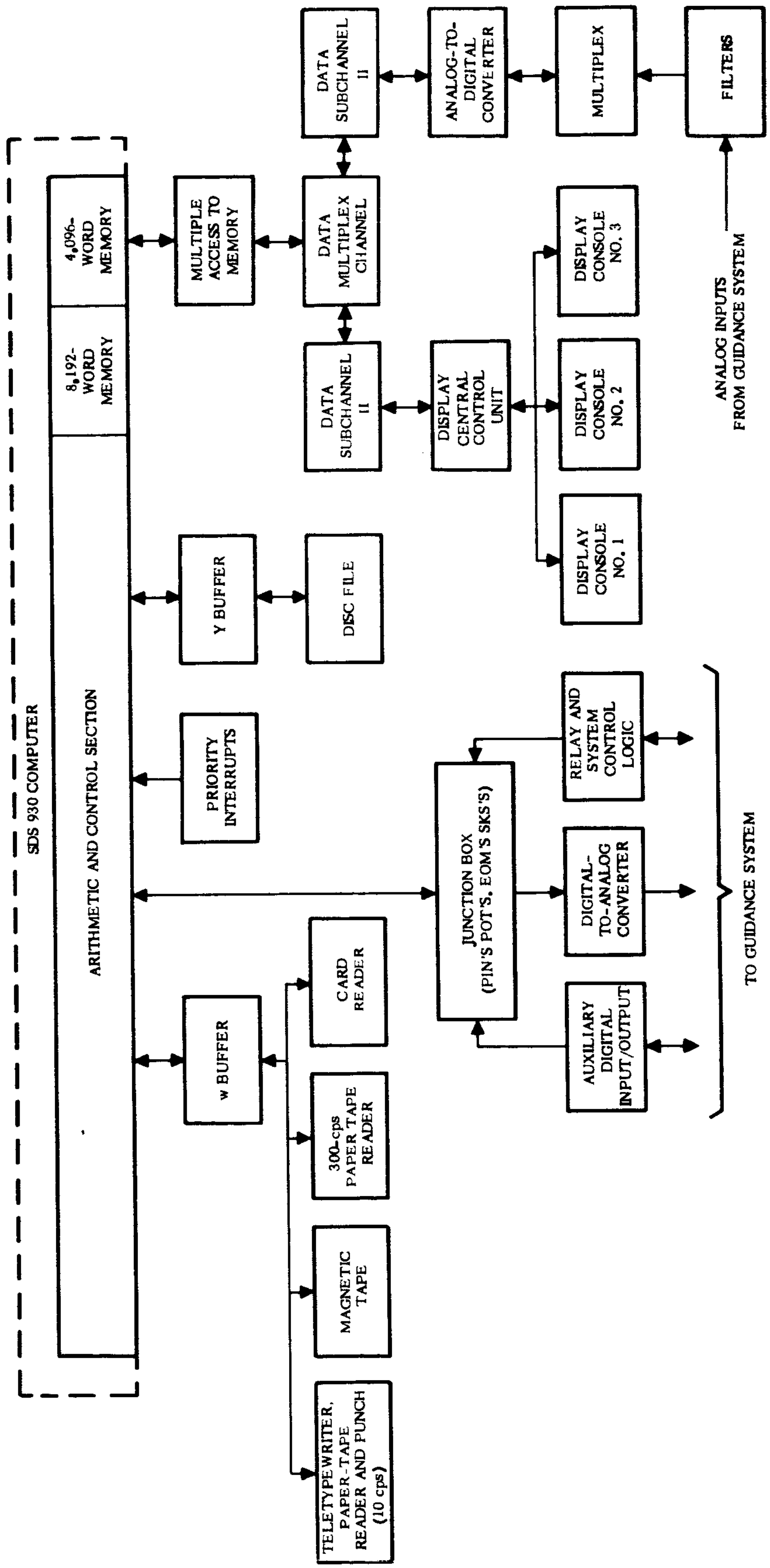


Figure 14. 4-2. Computer-Controlled Launch Set

14.4.2.1 ATE-2230 Automatic Test Set. The nucleus of the ATE-2230 is the SDS 930 Computer, a high speed, general purpose computer with a core storage capacity of 12,288 words. A priority interrupt system is provided to suspend execution of the in-process program when the guidance system or external timing signals demand immediate processing. Standard input/output devices provided consist of a magnetic tape unit, a desk file storage unit, a teletypewriter, a card reader, and a paper tape reader and punch. The processing and control of analog signals is accomplished with digital-to-analog (D/A) and analog-to-digital (A/D) converters. Digital logic circuitry allows single and 24 bit information to be processed in or out of the computer.

14.4.2.2 DD-10 Display System. The DD-10 Display System provides alphanumeric status and control information on the face of a cathode ray tube (CRT) and includes a keyboard in standard typewriter arrangement (see Figure 14.4-3) to allow remote station communication with the computer. The message composed by an operator is displayed on the face of the CRT and is not transmitted to the computer until it has been reviewed and any mistakes have been corrected.

14.4.2.3 Auxiliary Electronics. The guidance system analog and digital signals are normalized for compatibility with the SDS 930 computer. Special signal conditioners are provided for this purpose. Also, digital buffer circuits are provided to format and store digital information until the computer is ready to accept it. The

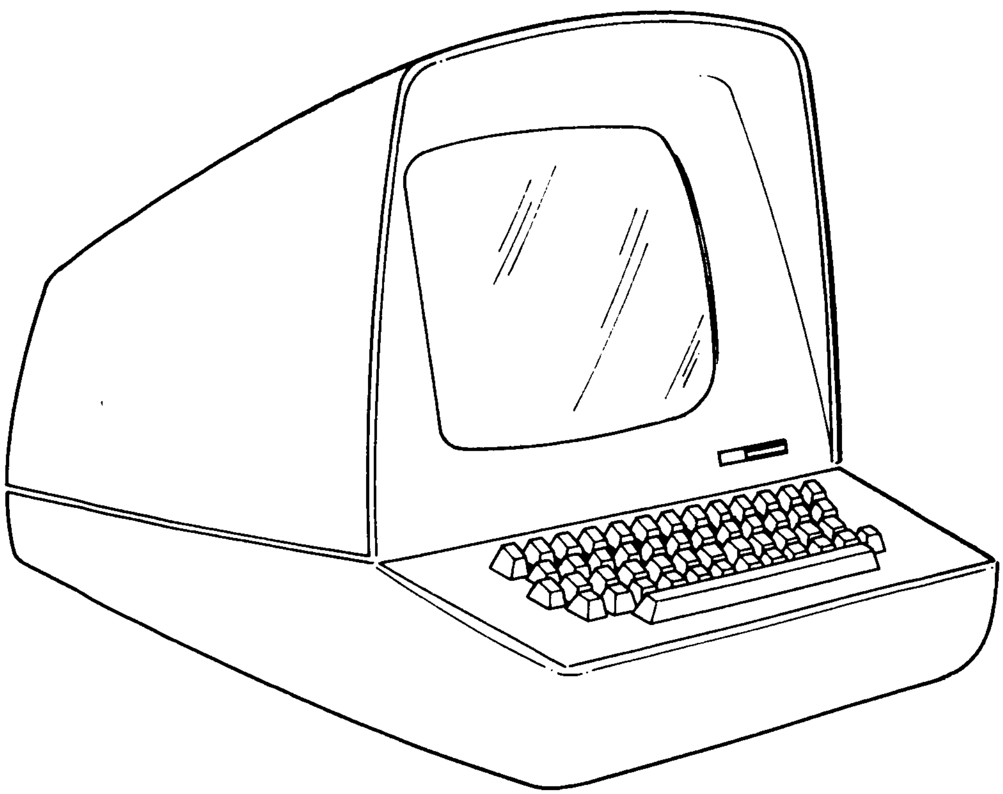


Figure 14.4-3. DD-10 Display Console

guidance system power turn on and turn off and sequencing through checkout and launch is controlled through the auxiliary electronics equipment racks.

14.4.2.4 Site Interface. The CCLS interface with the launch site is through a patch panel arrangement which allows selection of either launch pad (36A or 36B) for interconnection. Figure 14.2-1 shows the CCLS interconnection with either launch pad through the patch panels. The panels are not a part of the CCLS and are shown for reference only.

14.5 GUIDANCE LABORATORY GSE

Laboratory testing consists of both unit and system level testing. Unit level testing uses individual test fixtures and limited capability special purpose testers. A system test set performs tests on the complete MGS at a systems level. Tests conducted at the laboratory are more extensive than those possible at the launch site because a special mounting fixture in the laboratory allows the inertial platform to be oriented in various positions. In addition, at the unit level, other pieces of laboratory test equipment enable access to permanent storage in the computer.

14.5.1 UNIT LEVEL TEST EQUIPMENT. Unit level tests in the laboratory are performed on 2 of the 5 vehicle guidance system components, the Navigation Computer and the Signal Conditioner.

14.5.1.1 Computer Unit Level. Computer unit level tests enable an operator to load programs into the computer and verify the contents of the computer memory. The computer logic may also be exercised to determine proper operation. The following equipment is used to conduct the computer unit level tests:

a. Fill and Test Unit. This unit is used with a tape reader to enter words or taped programs into the computer's main memory and to test, troubleshoot, and maintain the computer. It is also used to load and verify the computer temporary storage with "d" and "j" values. The fill and test unit is shown in Figure 14.5-1.

b. Card Tester. This tester, Figure 14.5-2, is used to service the individual computer circuit cards (boards). It will check circuits such as flip-flops, read amplifiers, and associated logic networks.

c. Input/Output Test Set. This test set is used to test the input/output circuitry of the computer by injecting known input stimuli and monitoring the output responses. This test set is shown in Figure 14.5-3.

d. Marginal Test Set. This tester establishes or verifies the capability of the computer to operate over a specified range of marginal power conditions. See Figure 14.5-4.

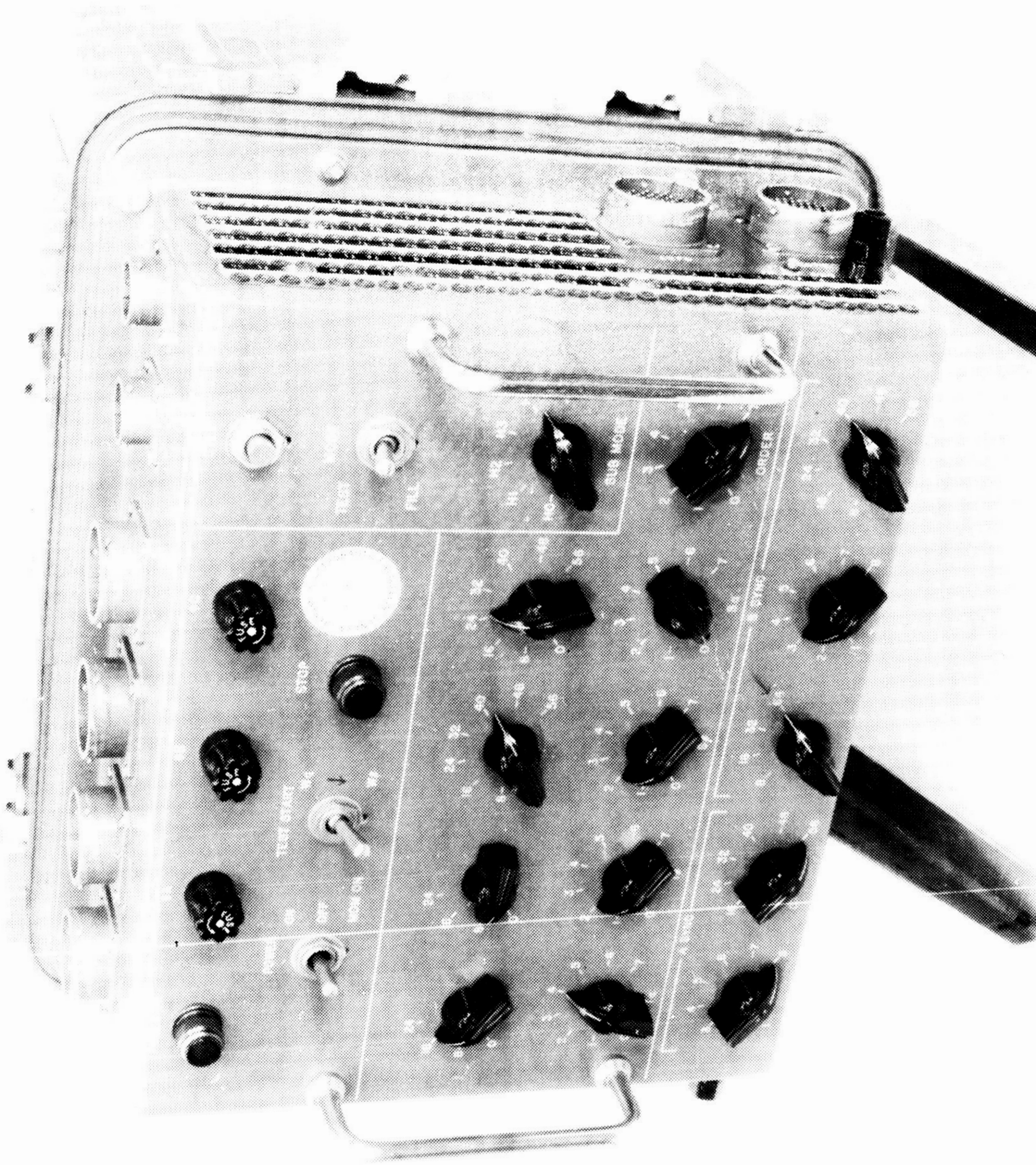


Figure 14.5-1. Fill And Test Unit

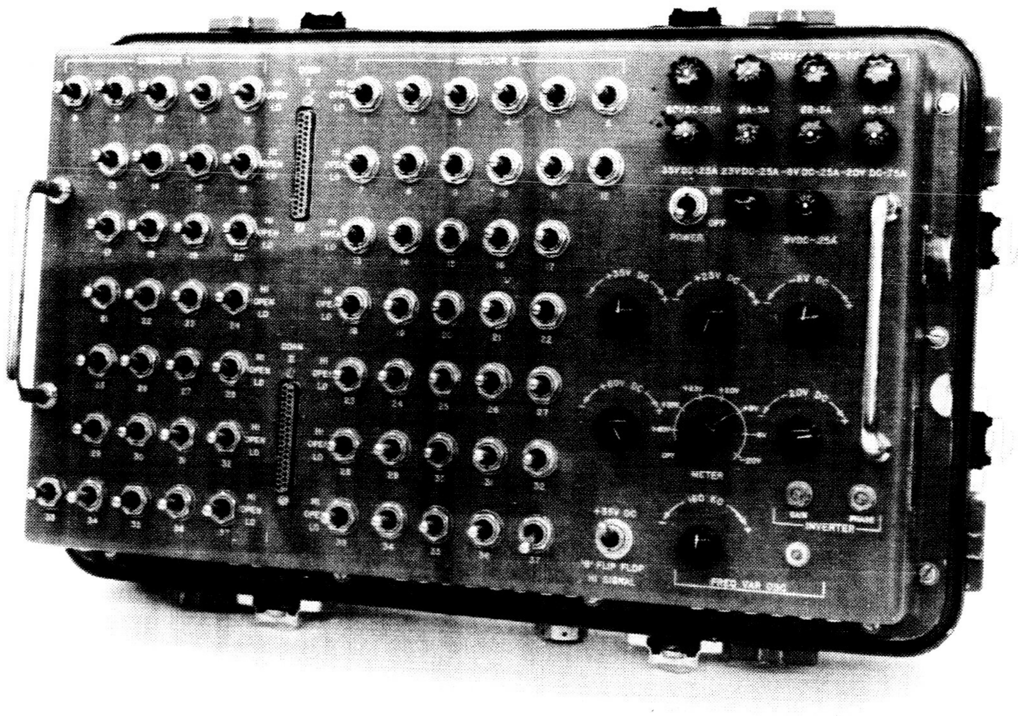


Figure 14.5-2. Card Tester

e. Tape Reader. The tape reader is a self-contained unit used with the fill and test unit to enter information onto the computer memory drum from pre-punched tape. This reader (Figure 14.5-5) is a pin sensing device and senses one tape character every 125 milliseconds.

f. Remote Load and Read Test Set. A description of this test set is presented in Paragraph 14.3.2.1. The laboratory test set also contains the necessary interface to permit addition of an ac-dc converter and a DVM read-out, see Figure 14.5-6. A RL&R junction box allows the use of the RL&R with either the Input/Output Tester or Function Generator during unit level testing of the guidance computer.

14.5.1.2 Signal Conditioner Unit Level. A Signal Conditioner Test Set (See Figure 14.5-7) allows unit level testing of the vehicleborne telemetry signal conditioner for functional integrity and proper scaling and calibration. Known stimuli are applied to the input and the responses measured at the signal conditioner output. A sandwich plug is used to permit the use of a second vehicleborne signal conditioner, if required.

14.5.2 SYSTEM LEVEL TEST EQUIPMENT. The system test set assembly is fabricated for general use in the hangar test area. The arrangement of the panels in

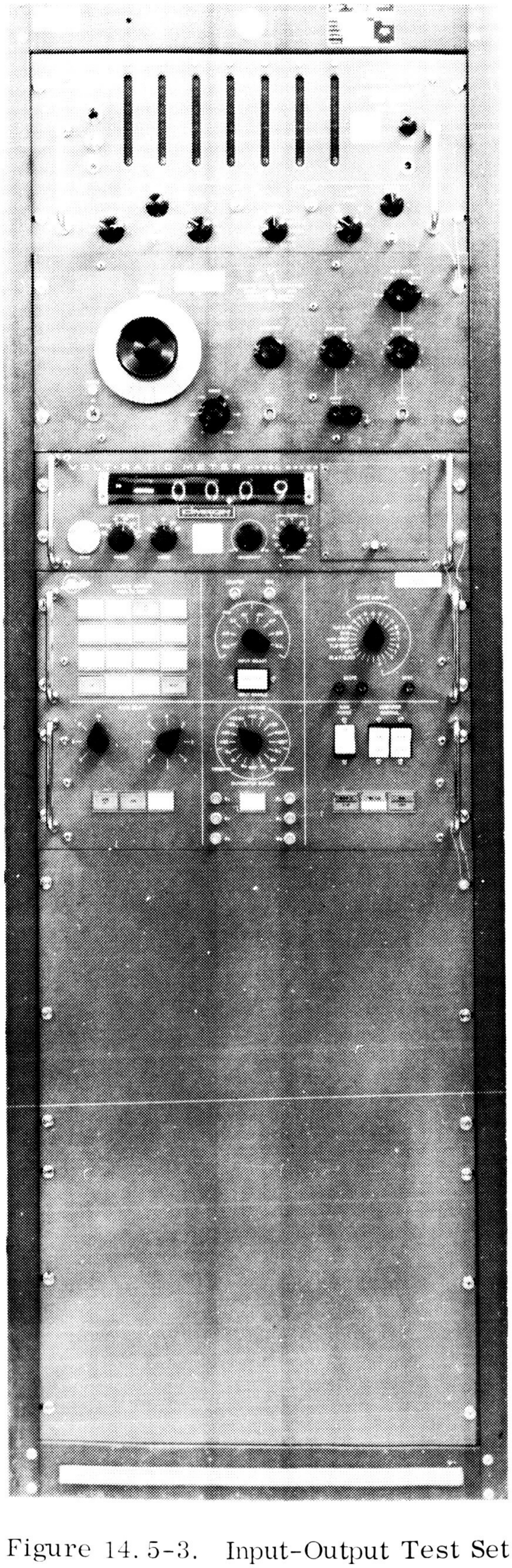


Figure 14.5-3. Input-Output Test Set

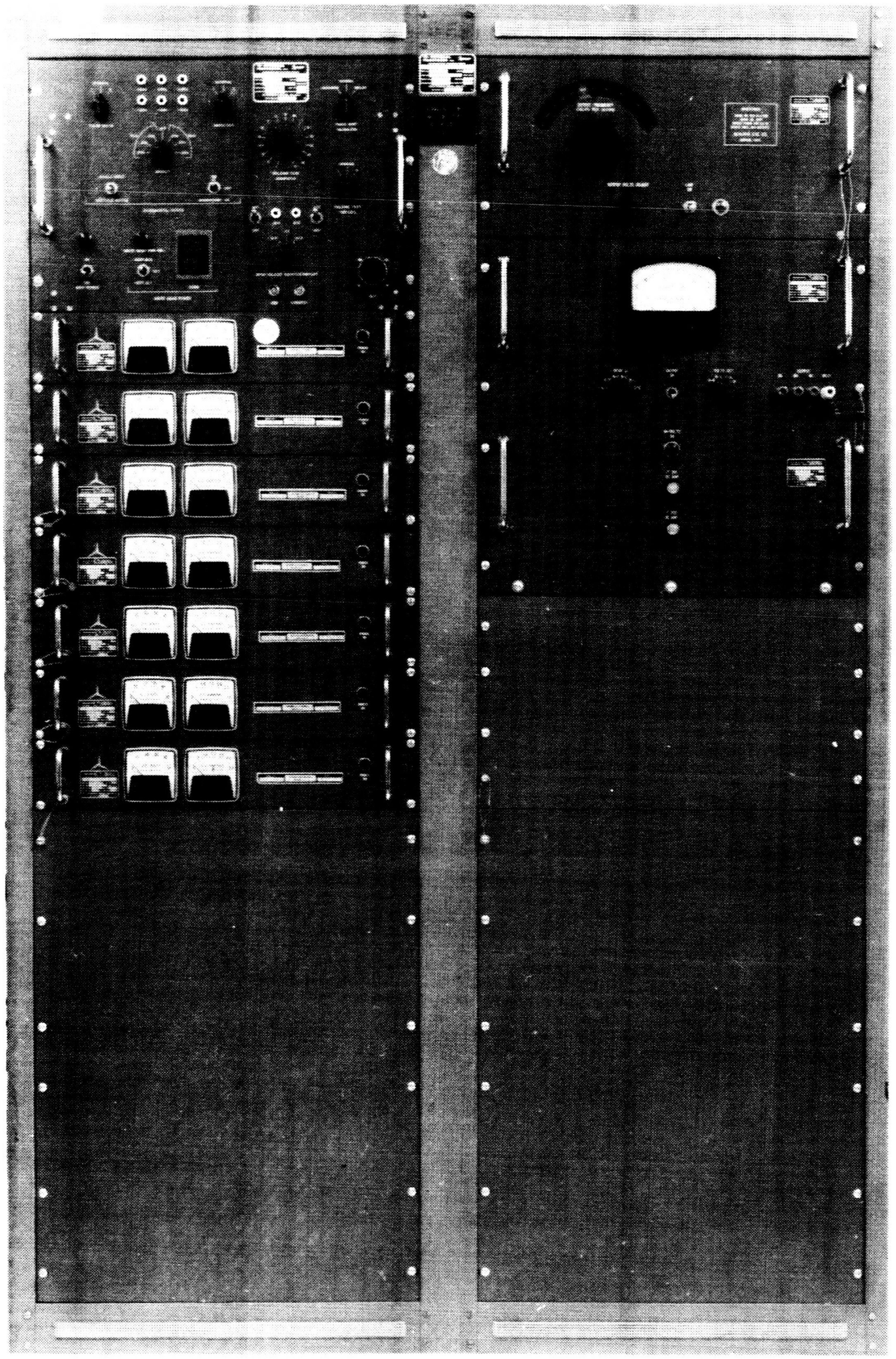


Figure 14.5-4. Marginal Test Set

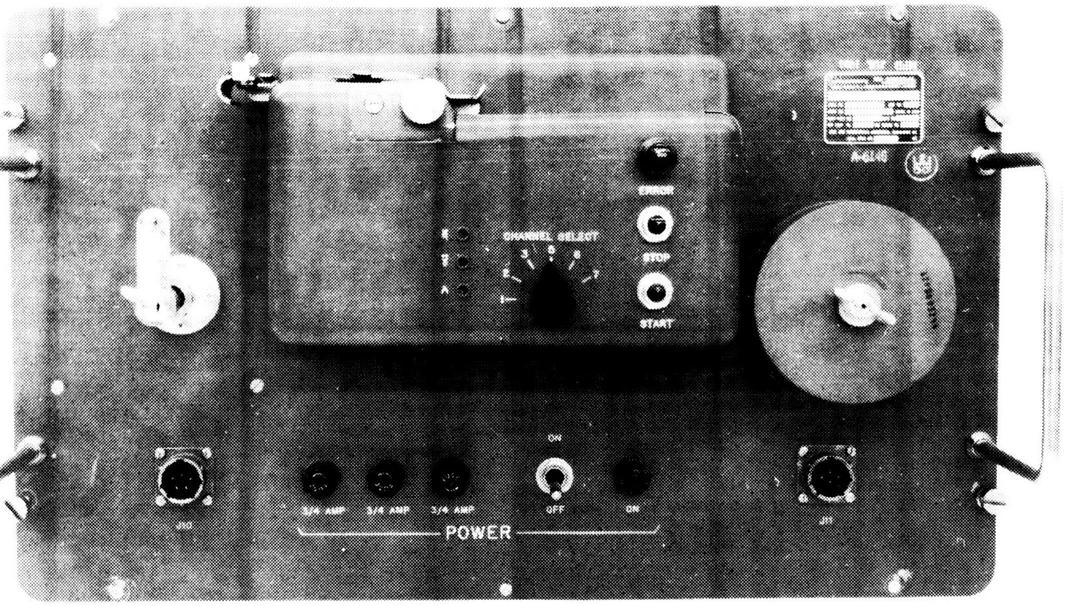


Figure 14.5-5. Tape Reader

the two bay rack of system test equipment is shown in Figure 14.5-8. This equipment consists of items manufactured by GD/C, Honeywell, and GFP assemblies.

With two exceptions, the panel functions of the system test set are similar to those described in Paragraph 14.3.2.1. The Recorder Counter Control and Recorder-Counter Relay Matrix are described in the following paragraphs.

14.5.2.1 Recorder-Counter Control. Contains the operating controls for selecting predetermined signals for routing to the chart recorder and electronic counter.

14.5.2.2 Recorder-Counter Relay Matrix. Establishes the signal routing selected by the control unit and also contains test points for monitoring output signals and insertion of external input signals.

The test set assembly equipment rack measures 69x45x30 inches and weighs approximately 300 pounds.

14.5.3 MGS MOUNTING EQUIPMENT. A test fixture is provided in the laboratory and hangar area for support of the MGS during checkout and test. This test fixture consists of the following major components:

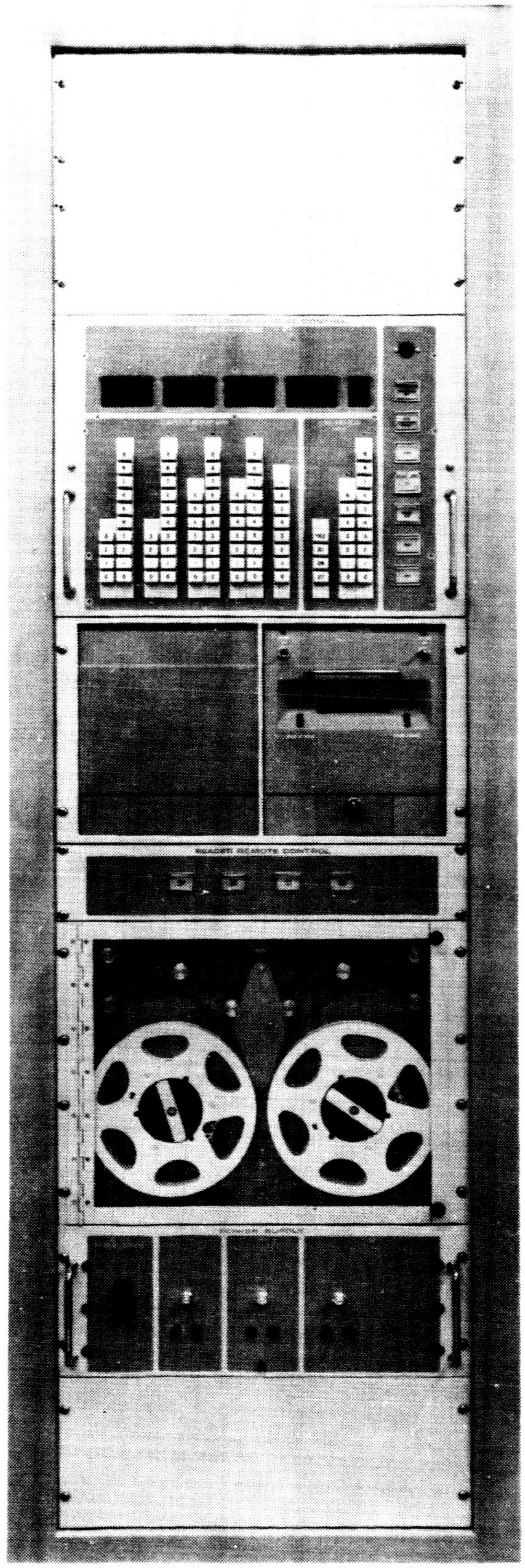


Figure 14.5-6. Remote Load and Read Test Set

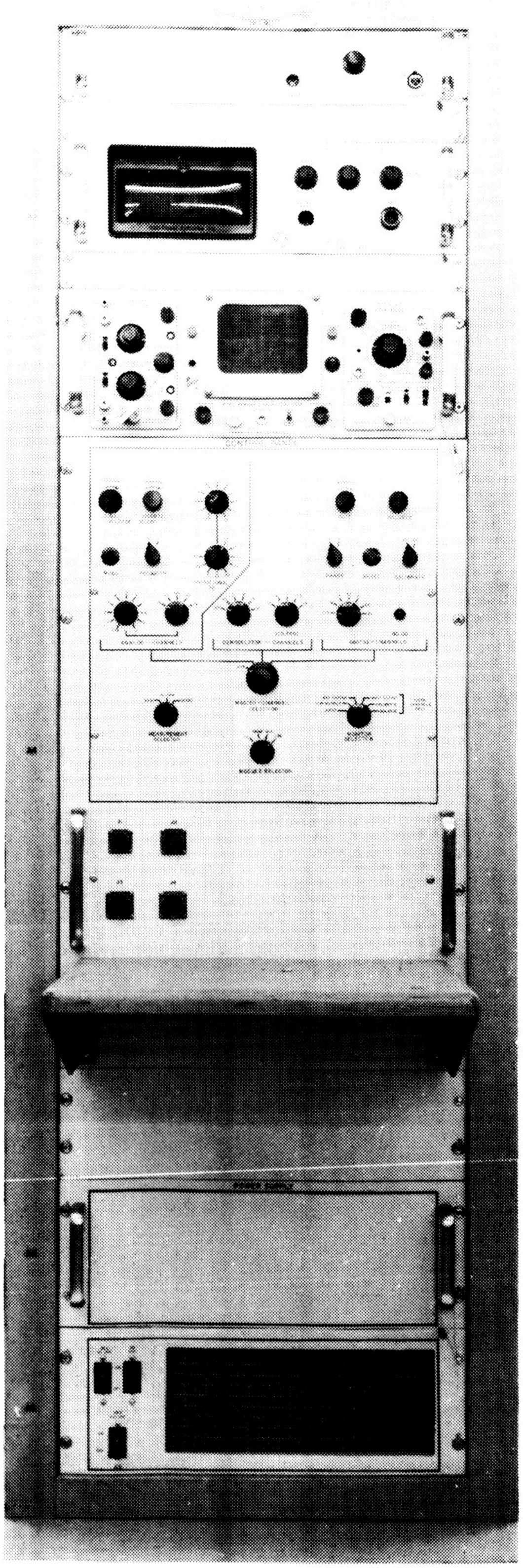


Figure 14.5-7. Signal Conditioner Test Set

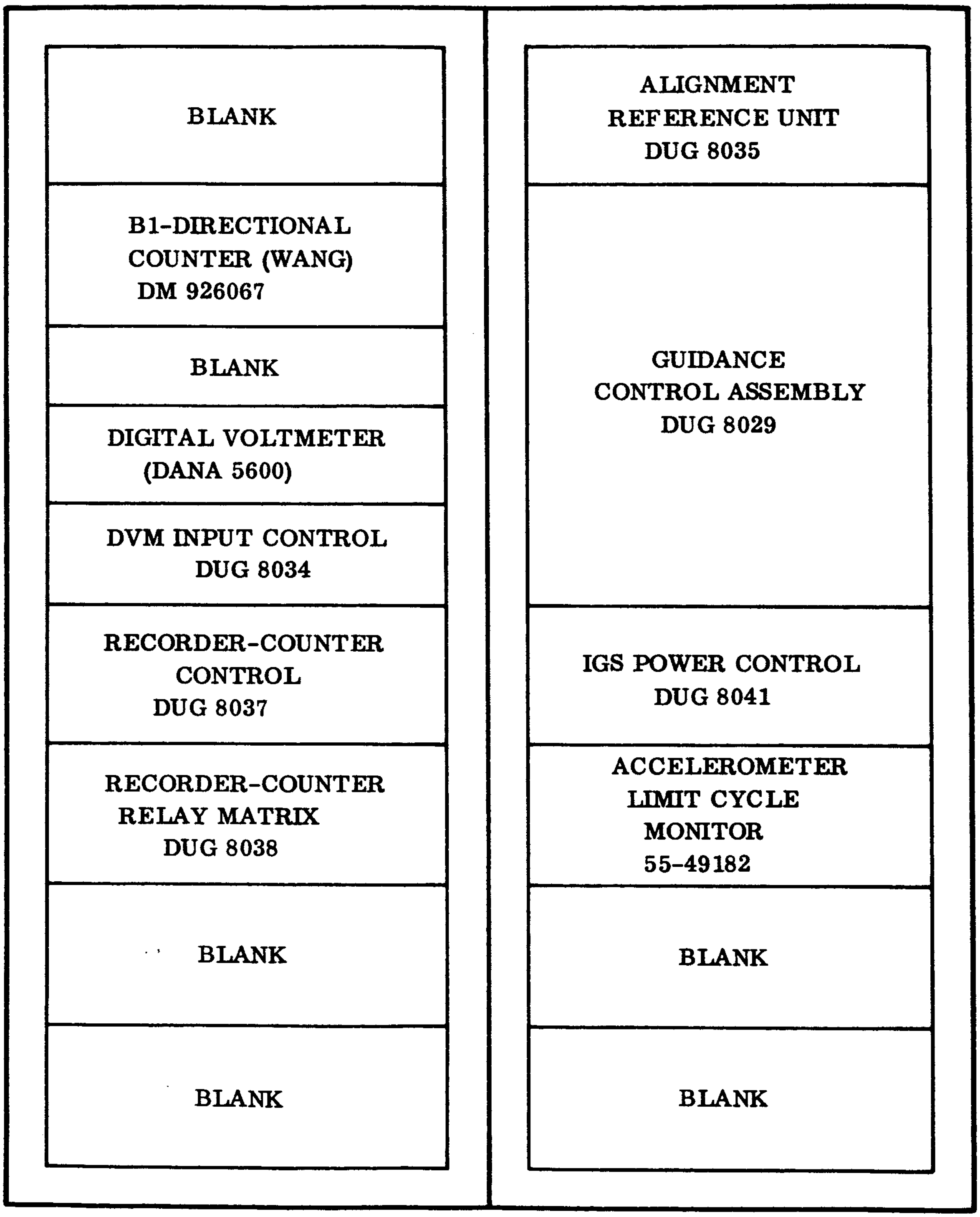


Figure 14.5-8. System Test Set Assembly

14.5.3.1 Platform Mount. The platform mount is a rigid plate suspended between self-aligning bearings. The mount has leveling screws and level bubbles for positioning the platform roll axis perpendicular to the local vertical. The platform case can be rotated 360 degrees about its axis and locked in any position.

14.5.3.2 Cart. The cart is mobile and can either be rolled or positioned firmly on the floor. Leveling screws are provided.

14.5.3.3 Autocollimator. An overhead mount and an autocollimator are provided for viewing reflecting surfaces on the gimbal with a vertical line of sight. The mount is adjustable and the autocollimator can be rotated ±5 degrees about axes parallel to the longitudinal and lateral axes of the platform. The platform table and cart are shown in Figure 14.5-9.

14.5.4 MAINTENANCE AND VALIDATION EQUIPMENT. The MGS maintenance and validation equipment used in the guidance laboratory consists of a sandwich plug group, a test point panel, differential voltmeter, signal conditioner test set (reference Paragraph 14.5.1), equipment for MGS validation, and an MGS simulator.

14.5.4.1 Sandwich Plugs. The sandwich plugs are designed to provide access to each line in the vehicleborne cables. The sandwich plug group consists of eight units:

a. Vehicle Power - Pulse Rebalance

b. Signal Conditioner - Pulse Rebalance

c. Platform - Platform Electronics

d. Programmer - Platform Electronics

e. Signal Conditioner - Platform Electronics

f. Platform - Pulse Rebalance

g. Computer - Pulse Rebalance

h. Computer - Programmer and Signal Conditioner.

The sandwich plug packages have a connector on one side and a three foot cable with a connector on the other side (Figure 14.5-10). These connectors mate with corresponding connectors on the MGS units. Lines through the sandwich plugs can be opened with a single-pole, single throw switch. Test points are inserted in the line on each side of the switch for monitoring voltages, inserting loads, and monitoring currents. The plugs contain fuses in lines when protection against short circuits is needed.

14.5.4.2 Test Point Panel. The test point panel is a portable testing apparatus which can be hand carried and is readily accessible. The test point panel and chassis are mounted in a carrying case 25 × 17-1/2 × 15-5/8 inches. Five cables, 10 feet long with mating test connectors, are furnished with each set.

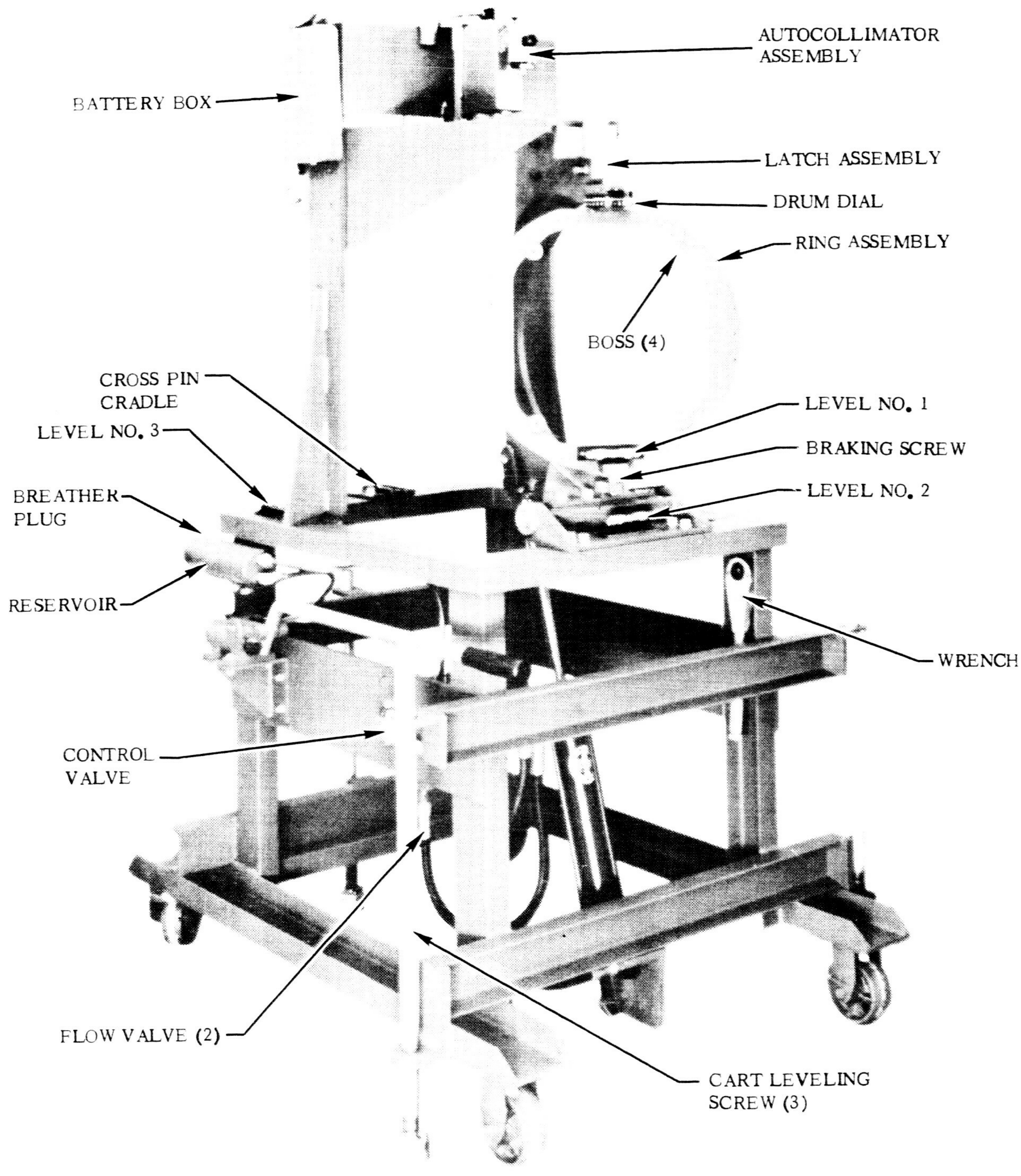


Figure 14. 5-9. MGS Mounting Equipment

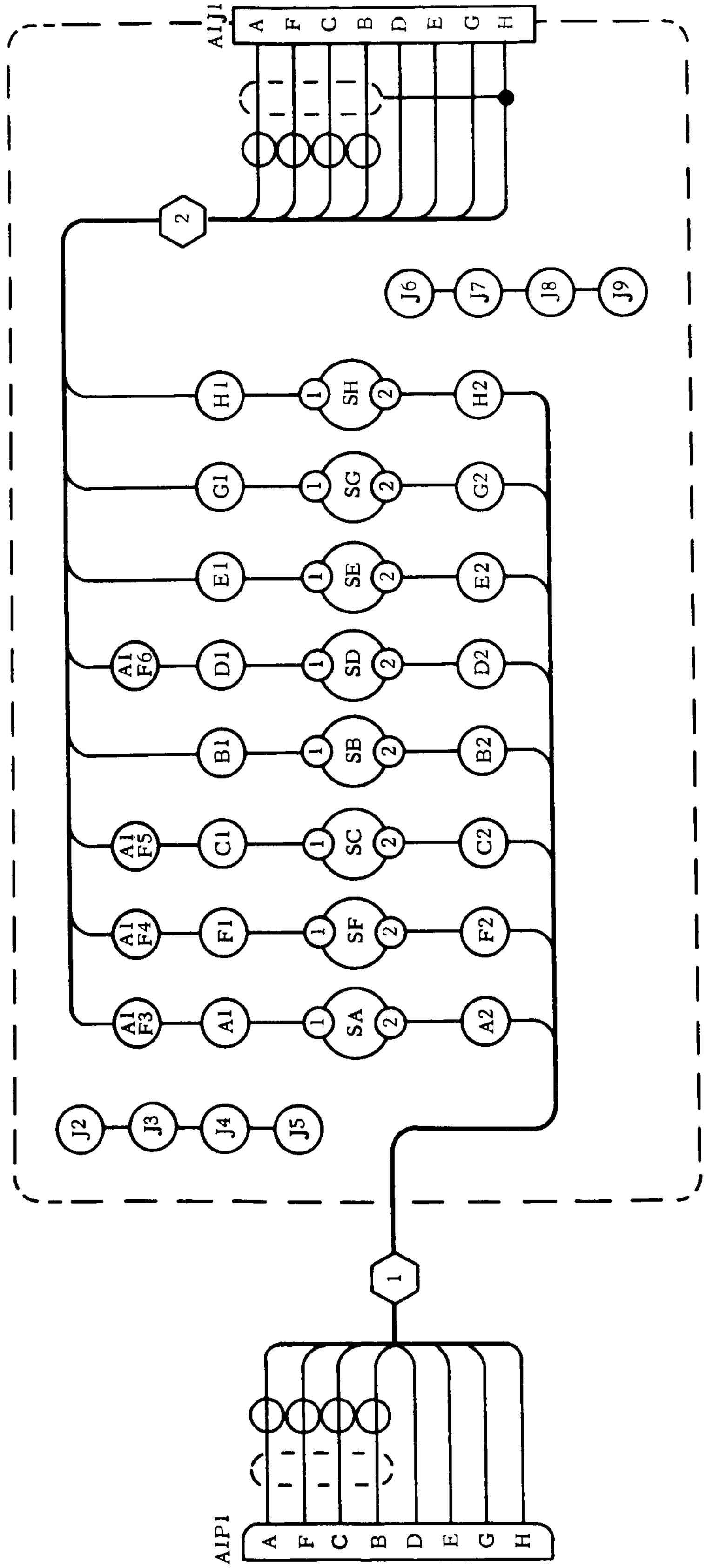


Figure 14.5-10. Typical Sandwich Plug Schematic

14.5.4.3 Differential Voltmeter. A John Fluke Model 803, Precision AC-DC Differential Voltmeter is typical of the meters necessary to meet performance specifications of the maintenance equipment. The output of this instrument is displayed on an in-line readout. The instrument can be used as a vacuum tube voltmeter when the output is displayed on the voltmeter scale.

14.5.4.4 MGS Validation Equipment. This equipment is a collection of "off the shelf" items of auxiliary test equipment such as the oscilloscope and digital voltmeter used in maintenance and validation of the MGS.

14.5.4.5 MGS Simulator. This unit monitors and GSE commands to the vehicleborne guidance system and simulates the vehicleborne guidance functions. It is used in the laboratory to validate the guidance GSE, Input/Output Test Set and the Function Generator. The MGS Simulator is described in more detail in Paragraph 14.6.

14.6 GUIDANCE GSE VALIDATION

The validation of the guidance GSE is performed prior to start of vehicle checkout for a launch, and at any other time that the site wiring or GSE is modified.

All guidance GSE validation is accomplished by means of a Missile Guidance System Simulator. While in the different control modes, the Simulator will provide go, no-go signals and/or calibrated responses to the GSE. This Simulator is allocated to the ETR Hangar H guidance laboratory and is moved to the service tower at Complex 36 when the launch control GSE validation is desired.

The Hangar H laboratory guidance GSE, except for the system test portion, has integral self-test capability or is validated with conventional lab instruments or special purpose test equipment.

The optical alignment group, which is comprised of the autotheodolite and its associated electronics, is validated by means of a reference reflecting porro prism (reference Figure 14.3-7) similar to the one installed on the guidance platform. All associated GSE circuitry is exercised during validation.

The Computer Controlled Launch Set (CCLS) has the inherent capability to conduct extensive and complex self-tests without additional hardware. The CCLS is programmed to use this capability to perform a complete self-test of the logic and peripheral equipment. Used in conjunction with the GD/C auxiliary equipment, the tests can be extended to include end-to-end system tests. Complete CCLS self-validation is accomplished before any guidance system checkout is started.

14.6.1 MISSILE GUIDANCE SYSTEM SIMULATOR. The MGS Simulator provides simulation of the vehicleborne guidance set and, when installed in the service tower, it interfaces with either the vehicle harness connectors or directly with the umbilical connectors. Primarily, simulation is accomplished by manual operation. Automatic or dynamic response circuits are used only where necessary to give an accurate indication of proper operation of the GSE.

The MGS Simulator rack assembly (Figure 14.6-1) is mounted on a four wheeled carriage. The rack measures 72 inches high, 24 inches wide, and 24 inches deep, and weighs approximately 800 pounds completely wired and with subassemblies mounted.

The following power input is required for the MGSS:

a. 115 ± 5% volts, 60 ± 1.2 cps, single phase, 8 amperes, 0.8 power factor.

b. 115 ± 5% volts, 400 ± 6 cps, three phase, each phase 1 ampere, 0.8 power factor.

14.6.2 LABORATORY GSE VALIDATION. The system test portion of the guidance laboratory GSE is validated in a manner similar to the launch control GSE. However, the laboratory GSE does not include the Launch-On-Time Decoder, the Remote Optical Control Panel, transfer room equipment, optical alignment autotheodolite and controls, and the Remote Load and Read unit is detached from the system test set.

14.6.3 COMPUTER TEST EQUIPMENT VALIDATION

14.6.3.1 Fill/Test Unit. Validation is performed by continuity checks between connector pins, while manipulating the unit switches. In addition, outputs of the integral power supplies, 5 flip flops, and the write amplifiers are measured.

14.6.3.2 Input/Output Tester. Validation of this unit requires the use of the MGS Simulator to stimulate the I/O Tester and a volt-ohmmeter to measure the outputs.

14.6.3.3 Marginal Test Unit. Validation of this unit requires the I/O Tester, the Fill/Test Unit, an oscilloscope, a Fluke differential voltmeter and an electronic counter.

14.6.3.4 Remote Load and Read Test Set. Validation is accomplished using the RL&R test portion of the MGS Simulator. The RL&R loads set of words into the MGS Simulator test register and then reads out the same words. Words are selected so as to energize the complete RL&R.

14.6.3.5 Tape Reader. Validation consists of running a test tape through the Tape Reader and observing output traces on an oscilloscope while controls are manipulated.

14.6.3.6 Function Generator. Validation uses the MGS Simulator in conjunction with an oscilloscope, electronic counter and volt-ohmmeter.

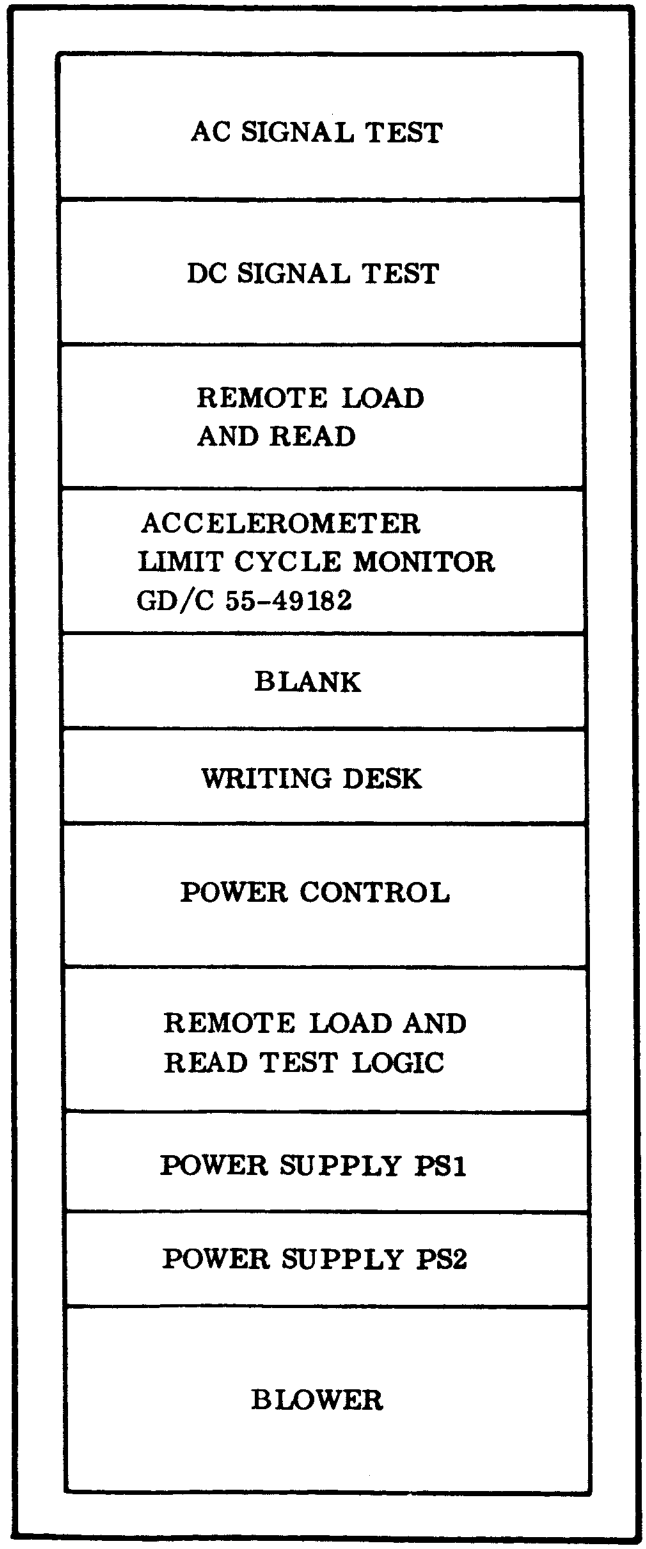


Figure 14. 6-1. Missile Guidance System Simulator, Front Panel Layout

SECTION XV

RF SYSTEMS

15.1 RANGE SAFETY COMMAND SYSTEM

A range safety command (RSC) system provides a method for terminating the flight of the Centaur vehicle and its payload if continued flight would endanger life, property, or the interests of the Government. Ground support equipment (GSE) is provided for the control, monitoring and checkout of the RSC during ground operations in preparation for a launch. Figure 15.1-1 is a block diagram of the RSC ground control system.

15.1.1 RANGE SAFETY COMMAND SYSTEM FUNCTION AND CONTROL. The second stage RSC system receives and decodes range safety commands transmitted by ETR range safety command transmitters. The command code tone modulation frequency and sequence, carrier frequency, and operating sequences are established by ETR. The commands utilized are:

a. Main Engine Cutoff (MECO). This command terminates thrust, but leaves the vehicle intact. It operates relays in the power control unit circuits to cause cutoff to the fuel being supplied to main engines, if they are operating, or to prevent the starting of the main engines, if they are not operating.

b. Destruct. The destruct command consists of the MECO command and a subsequent signal to activate the Centaur destructor and the Surveyor conical-shaped charge. The Centaur destructor is located on a fairing alongside the intermediate bulkhead. Upon receipt of the appropriate sequence of signals, the firing current is connected to initiators within the destructor. After a 90 $\pm$ 30 millisecond pyrotechnic time delay, the initiator fires, setting off a booster charge which, in turn, detonates the main charge. The main charge ruptures the bulkhead, separating the LH_2 and LO_2 tanks, thus dispersing the propellants. An operational conical-shaped charge is mounted on the payload adapter. The shaped charge is actuated by a mild detonating fuse. This fuse assembly is connected to the safe/arm initiator in the same manner that the main charge of the Centaur destructor is connected to its booster charge. Upon receipt of the proper sequence of signals, this pyrotechnic chain is activated, terminating in an explosive jet that pierces the spacecraft (Surveyor) engine and passes through the opposite side.

c. RF Disable. This command operates relays in the power control unit to switch the system from the vehicle battery power position to the external power position. The command may be transmitted by RF link or accomplished by the Centaur flight control programmer when orbital injection occurs.

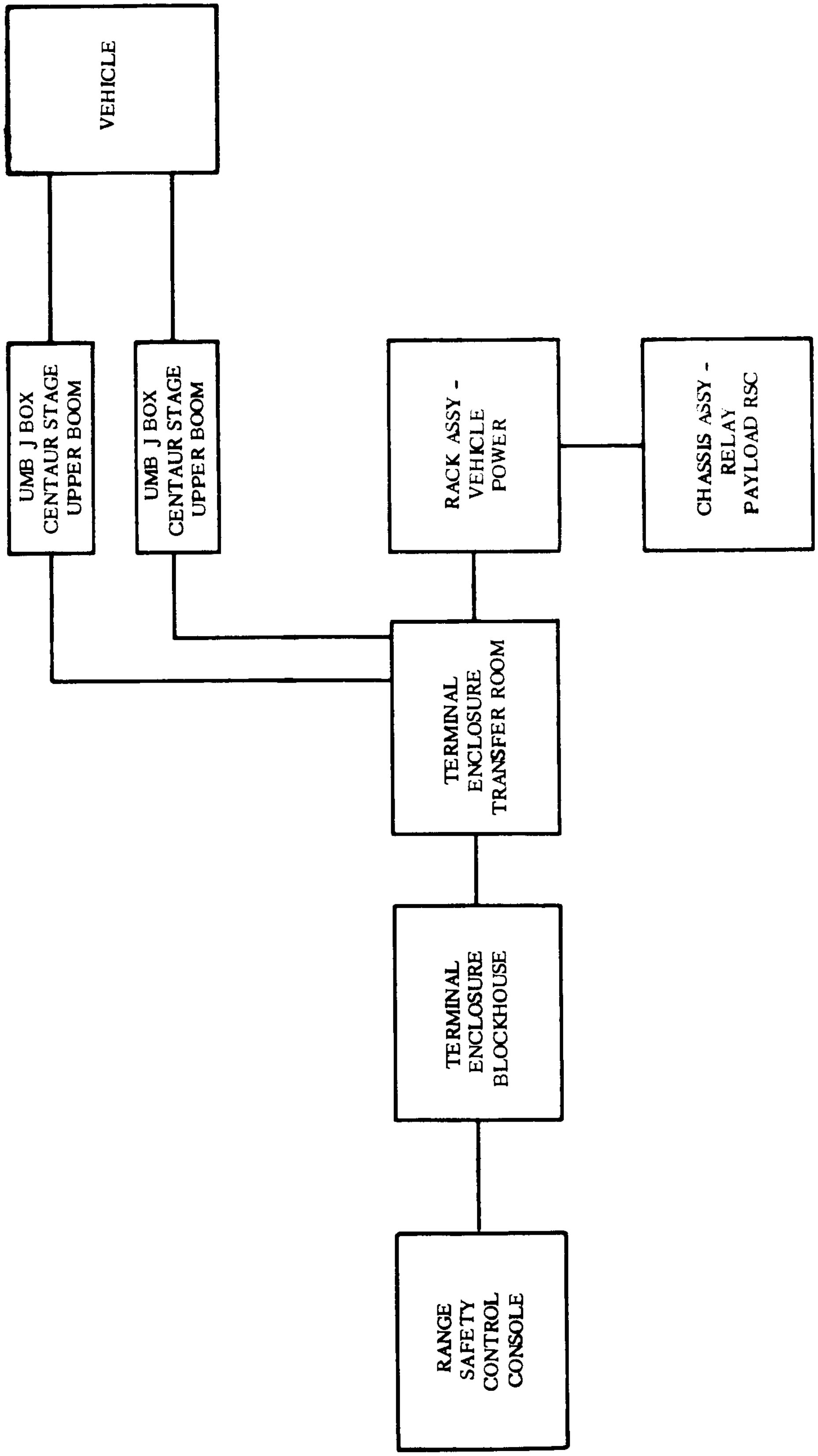


Figure 15.1-1. Block Diagram - Centaur Stage Range Safety Command

The system is designed to produce a destruct command upon indication of premature payload separation or Centaur/payload interface breakup. This destruct command is initiated when any two of the three separation switches sense separation of the payload with respect to the Centaur. When programmed Centaur MECO occurs, the inadvertent separation system is safed by a command output from the flight control programmer. This prevents commands from operating the destruct relays during normal payload separation.

During flight, the system operates from two independent range safety batteries which are completely separate from each other. During checkout and terminal countdown, ground electrical power is used. An inflight failure of one battery does not affect the operation of the system or the other battery. Either battery is adequate to produce the commands required by Air Force Missile Test Center (AFMTC) Regulations during countdown, liftoff, and until injection into orbit. The external-internal-off power control for the system is independent of the main vehicle power changeover mechanism.

The system is controlled by ground support equipment and provides control and monitoring signals for display and recording purposes. During ground operations all critical RSC functions are routed through a T-O (liftoff) umbilical connection.

The ground control of the Second Stage RSC System is accomplished by a control panel located in the Range Safety Console in the Blockhouse control room. The panel switches control the system through relays located in the transfer room in the Launch Services Building. The command functions include all functions required for safe aborts and verification of status of the RSC system prior to liftoff.

The system controls the Vehicle Range Safety Receivers, controls the Range Safety Battery heaters and arms the Destructor.

The system contains meters for monitoring the AGC and voltage of both receivers and the voltage of both batteries.

The arming of the Destructor is accomplished through a permit ladder. When the system is Ready, the Vehicle Range Safety System is isolated from all external power to insure that it is operating only on internal power.

The system includes an Inflight Disarming feature used to test the inflight safing of the Range Safety System.

The system is designed for ground checkout operation using an inert test substitution unit ("Green Box") in place of the Centaur destructor ("Red Box") and the payload (Surveyor) arm/safe unit.

15.1.2 MAJOR COMPONENTS. The RSC system's major components consist of vehicleborne equipment and GSE.

15.1.2.1 Vehicle System. The vehicleborne RSC system consists of two antennas, a ring coupler, two command receivers, a Centaur destructor, a payload arm/safe unit, a conical shaped-charge assembly, pyrotechnic harness assemblies, inadvertent separation switches, a power control unit, and the necessary RF transmission lines. Redundancy is accomplished with two separate and independent methods of receiving, decoding, and carrying out the command signals. The system reacts to commands received by either command receiver. No part of the system is attached to the payload. Figure 15.1-2 illustrates the system arrangement.

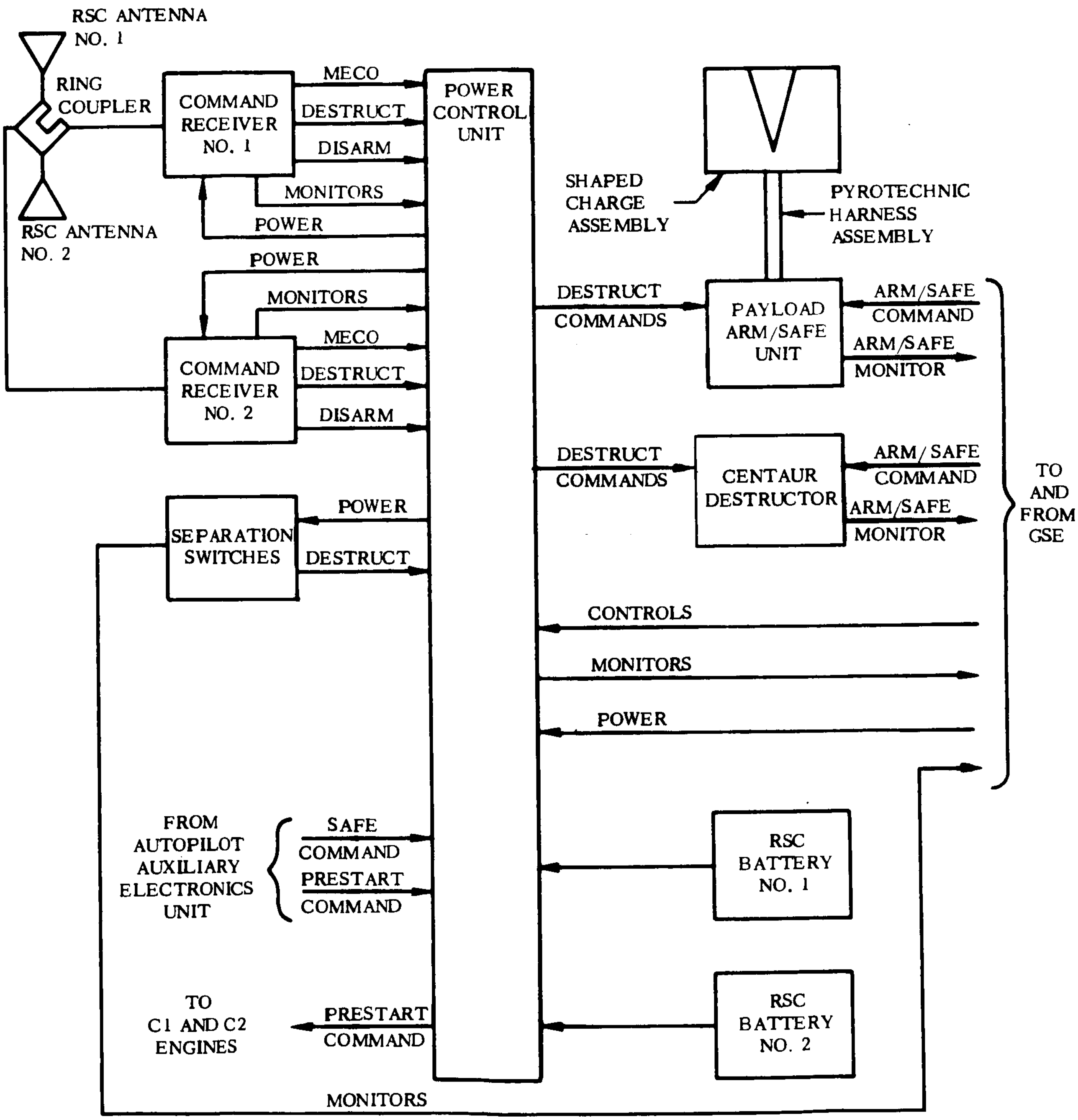


Figure 15.1-2. Block Diagram - Range Safety Command System

15.1.2.2 Ground Support Equipment. The GSE for control and monitoring of the vehicleborne range safety system consists of a second stage control and monitor panel, a payload control and monitor panel, and associated relay logic. Equipment is also provided at the launch site for both open and closed loop checkout and test of the vehicle RSC system.

15.1.2.2.1 Control and Monitoring. The control and monitoring panels for the second stage and payload RSC are mounted in a console located in the blockhouse. The relay logic chassis assemblies are located in the transfer room of the launch and services building. The control and monitoring panels for the RSC control second stage and payload (Surveyor) RSC are shown in Figure 15.1-3. A functional description of the switches and lights on the Second Stage and payload range safety command panels is given in Table 15.1-1. A block diagram of the RSC system showing hardware interfaces with other GSE is presented in Figure 15.1-4 and a listing of interface signals is given in Table 15.1-2. An elementary schematic of the RSC Control Second Stage is presented in GD/C Drawing 55-98041 and 55-98052.

TABLE 15.1-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON SECOND STAGE RANGE SAFETY COMMAND PANEL

Controls or Indicators	Functions
RSC Control Second Stage Panel	
SYSTEM POWER Switch	Turns the Second Stage Range Safety Command System power on. POWER ON indicator illuminates when power is on.
PSS CLEARANCE Switch	Allows the RSC Receivers to be turned on, allows External and Internal commands to be given and the Destructor to be armed. While off it acts as an interlock to prevent those functions from taking place. PSS CLEARANCE indicator illuminates when the switch is on.
RECEIVER NO. 1 Power Switch	Provides +28 vdc to RSC Receiver No. 1. It is inoperative until the PSS CLEARANCE switch is turned on. RECEIVER NO. 1 ON indicator illuminates when Receiver No. 1 power is on.

TABLE 15.1-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON SECOND STAGE RANGE SAFETY COMMAND PANEL (Continued)

Control or Indicators	Function
RSC Control Second Stage Panel (Continued)	
RECEIVER NO. 2 Power Switch	Provides +28 vdc to RSC Receiver No. 2. It is inoperative until the PSS CLEARANCE switch is turned on. RECEIVER NO. 2 ON indicator illuminates when Receiver No. 2 power is on.
RECEIVER NO. 1 Changeover Switch	Provides for selection of either OFF, INTERNAL, or EXTERNAL power for RSC Receiver No. 1. RECEIVER NO. 1 INTERNAL indicator or EXTERNAL indicator will illuminate if INTERNAL or EXTERNAL power is on.
RECEIVER NO. 2 Changeover Switch	Provides for selection of either OFF, INTERNAL or EXTERNAL power for RSC Receiver No. 2. Receiver No. 2 INTERNAL indicator or EXTERNAL indicator will illuminate if INTERNAL or EXTERNAL power is on.
BATTERY CONTROL Switch	Provides power to the RSC battery heaters. Battery HEATERS ON indicator illuminates when power is on to the heaters.
BATTERY HEATER CURRENT Monitor Indicators	Batt No. 1 and No. 2 HTR current indicators illuminate when the heaters are cycling.
ARM/SAFE Switch	Used to arm or safe the Destructor. It is inactive in the ARM position until the PSS CLEARANCE Switch is on, if there is a Destruct signal present, or if Surveyor Auto Destruct is armed. The DESTRUCTOR ARMED/SAFE indicators illuminate to indicate the status of the Destructor.

TABLE 15.1-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON SECOND STAGE RANGE SAFETY COMMAND PANEL (Continued)

Controls or Indicators	Function
RSC Control Second Stage Panel (Continued)	
RECEIVER NO. 1/RECEIVER NO. 2 AGC Meters	Monitor Receiver No. 1 and Receiver No. 2 analog AGC.
RECEIVER NO. 1/BATTERY NO. 1 Switch	Selects either Receiver No. 1 voltage or RSC Battery No. 1 voltage input for the d-c voltmeter above it. The meter monitors either open circuit battery voltage or input voltage to the receiver.
RECEIVER NO. 2/BATTERY NO. 2 Switch	Selects either Receiver No. 2 voltage or RSC Battery No. 2 voltage input for the d-c voltmeter above it. The meter monitors either open circuit battery voltage or input voltage to the receiver.
RSC READY Indicator	Illuminates when Receiver No. 1 and Receiver No. 2 are both on internal power, the Destructor is armed, and a MECO Reset signal is present. The presence of the Ready signal removes external power from the RSC receivers. It illuminates also on signal from the Launch Control Simulator.
ISOLATE Indicator	Illuminates when the RSC System is Ready and there is no external power connected to either RSC Receiver. It indicates that the system is completely isolated from external power and is on internal power only.
DESTRUCT NO. 1 Indicator	Indicates when a Destruct signal has been received by RSC Receiver No. 1.
DESTRUCT NO. 2 Indicator	Indicates when a Destruct Signal has been received by RSC Receiver No. 2.
RF DISABLE NO. 1 Indicator	Indicates an RF Disable signal at RSC Receiver No. 1 while on external power.
RF DISABLE No. 2 Indicator	Indicates an RF Disable signal at RSC Receiver No. 2 while on external power.

TABLE 15.1-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON SECOND STAGE RANGE SAFETY COMMAND PANEL (Continued)

Control or Indicators	Function
RSC Control Second Stage Panel (Continued)	
RECEIVER NO. 1 MECO Indicator	Indicates that a Main Engine Cutoff signal is present at RSC Receiver No. 1 while on external power.
RECEIVER NO. 2 MECO Indicator	Indicates that a Main Engine Cutoff signal is present at RSC Receiver No. 2 while on external power.
MECO Indicator	Indicates that a Main Engine Cutoff signal is present at RSC Receiver No. 1 or No. 2 when the system is on internal power. A MECO Reset command is necessary to reset relays to their normal condition following the MECO signal.
MECO RESET Switch	Resets the relays that are latched up by a MECO signal while the system is on internal power MECO RESET indicator illuminates when MECO Reset command is given.
BATTERY 1 OVERTIME/ BATTERY 2 OVERTIME Indicators	Connected to the Second Stage Monitor Panel to indicate when the RSC Batteries have been used for a length of time on the ground such that any further use would endanger the useful life of the batteries while airborne. These indicators are an indication to switch from internal to external power.
RF DISABLE Indicator	Indicates that the airborne Range Safety system has been switched to external by an RF link to prevent destruction of the vehicle.
RF DISABLE RESET Switch	Resets the airborne RF Disable relays and re-establishes the external command while on the ground after an RF Disable signal has switched the system to External power.

TABLE 15.1-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND INDICATORS ON SECOND STAGE RANGE SAFETY COMMAND PANEL (Continued)

Control or Indicators	Function
RSC Control Second Stage Panel (Continued)	
	RF DISABLE RESET indicator illuminates when the RESET switch has been actuated.
RECEIVER 1 CHANNEL 5 Indicator	Indicates that an RF coded signal is present at RSC Receiver No. 1 when it is on External power.
RECEIVER 2 CHANNEL 5 Indicator	Indicates that an RF coded signal is present at RSC Receiver No. 2 when it is on External power.
Surveyor RSC Panel	
SYSTEM POWER Switch	Turns the Surveyor RSC system power on. The system POWER ON indicator illuminates when power is on.
SEPARATION Switches	Energizes (ARM) or de-energizes (SAFE) the separation switches in the inadvertent separation system. The AUTO. DEST. ARMED or AUTO. DEST. SAFE indicator illuminates depending upon condition of separation switches.
DESTRUCT Switch	Used to arm or safe the payload destruct system. The DESTRUCT ARM and DESTRUCT SAFE indicators reflect the status of the payload ARM/SAFE unit.
SYSTEM STATUS Indicators	Indicate PSS CLEARANCE, SEP. SW. MONITOR, and SYSTEM READY.

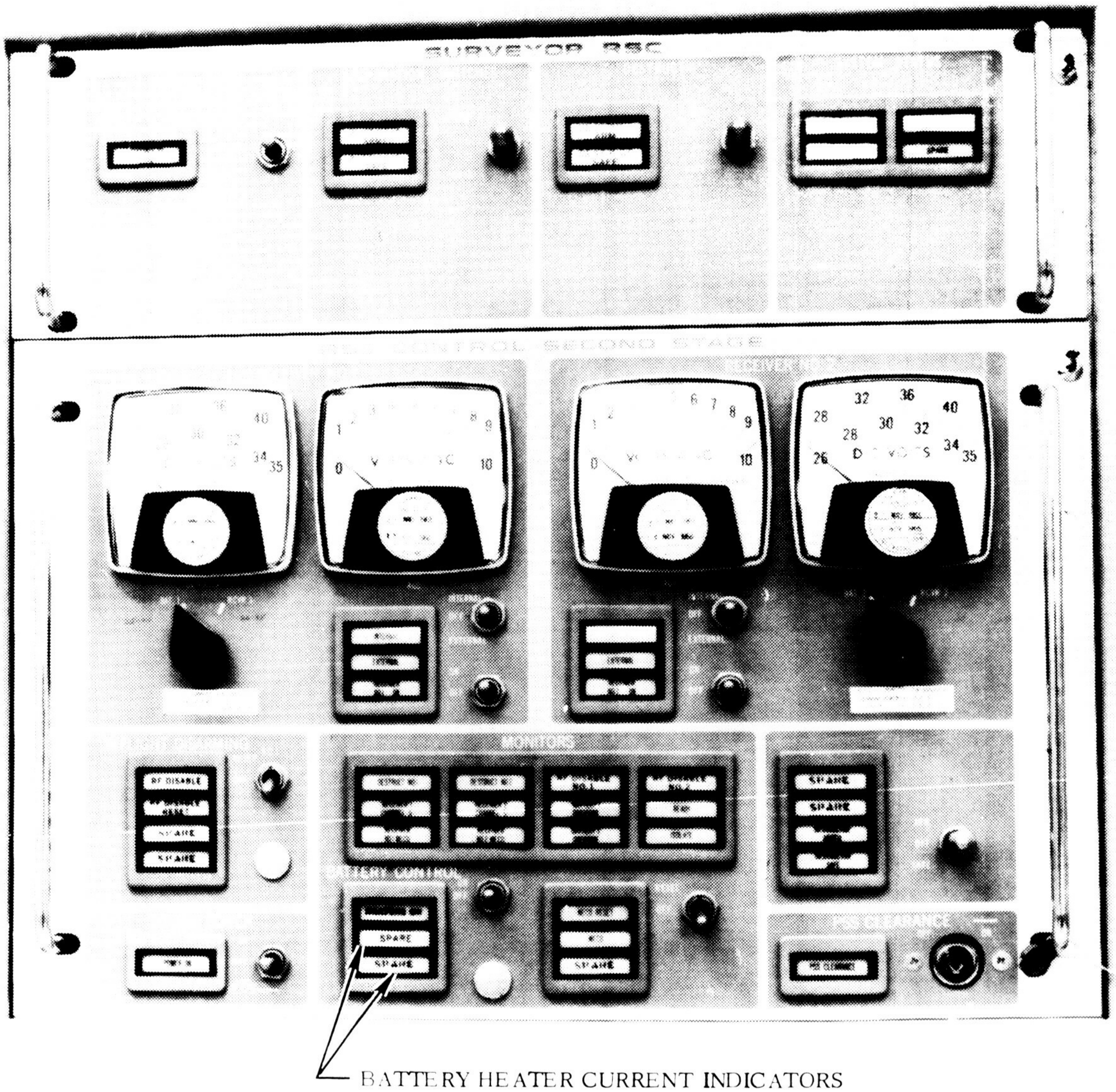


Figure 15.1-3. RSC Control and Monitoring Panels

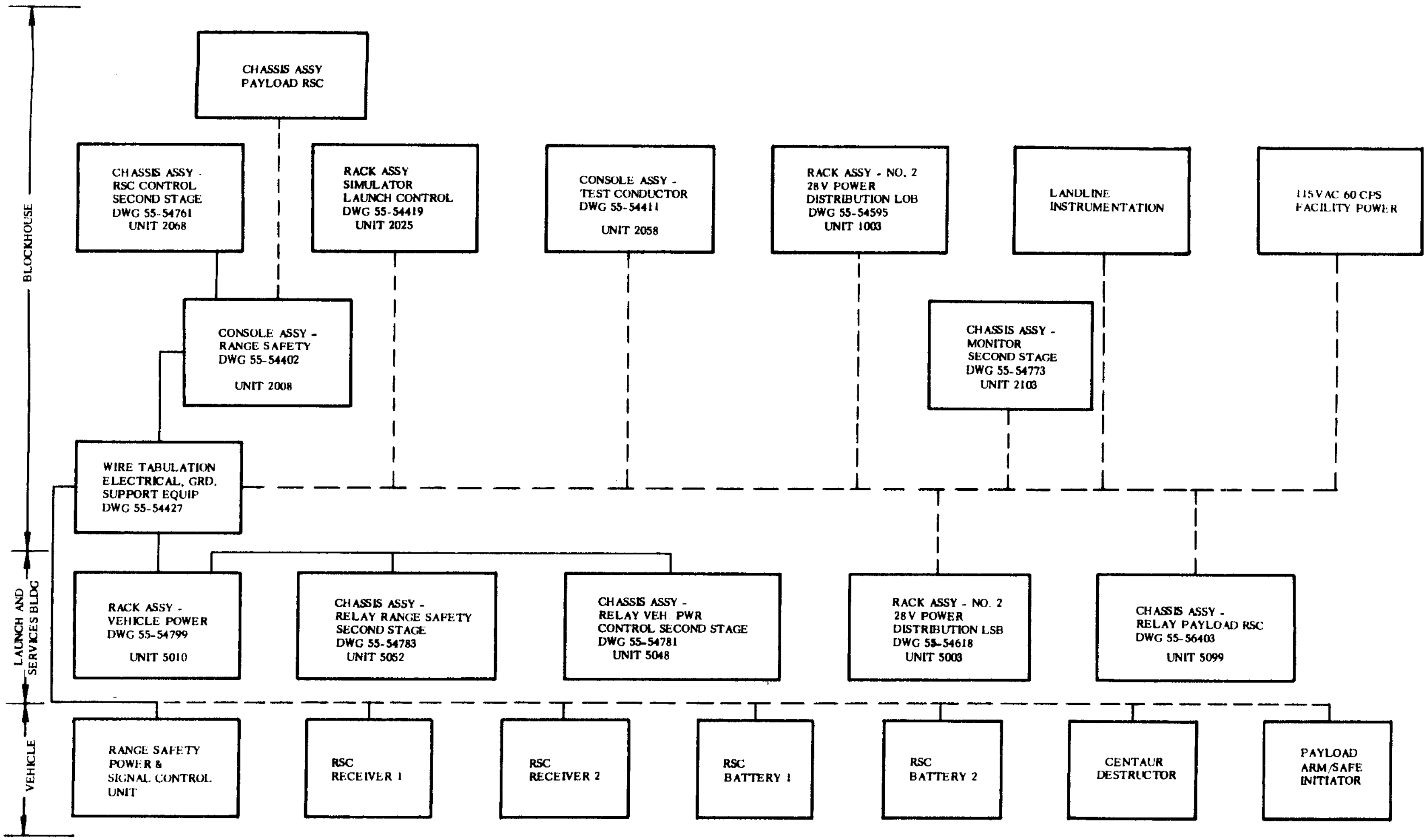


Figure 15.1-4. Block Diagram - Range Safety Command System Second Stage

TABLE 15.1-2. INTERFACE SIGNALS

Signal	Description
a. Receiver No. 1 Power On b. Receiver No. 2 Power On c. Destructor Armed d. Destructor Safe e. Dest. 1 f. Dest. 2 g. MECO h. MECO Reset i. Ready j. Receiver No. 1 Internal k. Receiver No. 1 External l. RF Disable Monitor m. Receiver No. 2 Internal n. Receiver No. 2 External o. Battery No. 1 Voltage p. Battery No. 2 Voltage q. RF Disable No. 1 r. RF Disable No. 2 s. MECO No. 1 t. MECO No. 2	Signals Recorded by Instrumentation Landlines
RECEIVER POWER ON	28 vdc is sent from the Range Safety Relay Chassis whenever either RSC Receiver has external power On, and to the Receiver 1 and 2 total time meters on the Second Stage Monitor Panel.
RECEIVER NO. 1 EXTERNAL MONITOR	Receiver No. 1 External monitor signal is sent to the Pad Safety Officer's Relay Chassis.
RECEIVER NO. 2 EXTERNAL MONITOR	Receiver No. 2 External monitor signal is sent to the Pad Safety Officer's Relay Chassis.
RECEIVER NO. 1 INTERNAL MONITOR	Receiver No. 1 Internal monitor signal is sent to the Pad Safety Officer's Relay Chassis and to RSC Battery No. 1 timer on the Second Stage Monitor Panel.

TABLE 15.1-2. INTERFACE SIGNALS (Continued)

Signal	Description
RECEIVER NO. 2 INTERNAL MONITOR	Receiver No. 2 Internal monitor signal is sent to the Pad Safety Officer's Relay Chassis and to RSC Battery No. 2 timer on the Second Stage Monitor Panel.
DESTRUCTOR ARMED MONITOR	A Destructor Armed monitor signal goes to the Pad Safety Officer's Relay Chassis.
DESTRUCTOR SAFE MONITOR	A Destructor Safe monitor signal goes to the Pad Safety Officer's Relay Chassis.
DESTRUCTOR 1 MONITOR	A Destruct 1 monitor signal goes to the Pad Safety Officer's Relay Chassis.
DESTRUCTOR 2 MONITOR	A Destruct 2 monitor signal goes to the Pad Safety Officer's Relay Chassis.
MECO 1 MONITOR	A MECO 1 monitor signal goes to the Pad Safety Officer's Relay Chassis.
MECO 2 MONITOR	A MECO 2 monitor signal goes to the Pad Safety Officer's Relay Chassis.
READY	A Ready signal goes to the Pad Safety Officer's Relay Chassis and to the Test Conductor's Console. The Ready light can also be activated by a signal from the Launch Control Simulator.
DESTRUCTOR 1B/DESTRUCTOR 2B MONITORS	A Destructor 1B and a Destructor 2B monitor signal go to the Surveyor RSC Relay Chassis.
SEPARATION SWITCH MONITOR	A Separation Switch monitor signal comes from the Surveyor RSC Relay Chassis.

TABLE 15.1-2. INTERFACE SIGNALS (Continued)

Signal	Description
BATTERY NO. 1/BATTERY NO. 2 OVERTIME	An overtime signal comes from the Second Stage Monitor Panel whenever the RSC Batteries have been used for a length of time on the ground such that any further use would reduce their useful airborne life.

15.1.2.2.2 Checkout Equipment. Equipment is provided for both open and closed loop checkout of the vehicle RSC system. This equipment provides an RF signal with calibrated attenuation and various tone combinations for the purpose of performing checkout of the RSC system after vehicle erection.

a. Open Loop Checkout. When the second stage (Centaur) insulation panels are installed, the RSC system is checked by open loop operation. The Range Safety Command Destruct transmitter is used for this operation. To ensure the reception of adequate signals from the transmitter with the service tower in place, the signals are received by a tower mounted antenna. This antenna is connected by coaxial cable to a relay antenna which points towards the vehicle RSC antenna. Also there is a Government furnished (GFE) RSC receiver mounted in a RSC test set for monitoring the range transmitter command signals. This test set is located in the blockhouse. The open loop RSC checkout system is shown in Figure 15.1-5. The system is controlled by manual adjustment of the RF command signal characteristics at the Range Command Transmitter. The major components of this system are as follows:

   (1) Range Safety Command Destruct Transmitter
   (2) Range Command Transmitter Monitor, consisting of GFE horn antenna, RG-9/U coaxial cable and a GFE RSC receiver.
   (3) Helical Antenna, GD/C No: 80-09908-001 (Andrew 19110A-5L).
   (4) Corner Reflector Antenna, GD/C No. 80-09900-013 (Andrew 3608A-2).
   (5) Antenna Coupler, GD/C No. 55-56101.
   (6) Coaxial Cable - Flexible, Military Design, RG225 B/U.

b. Closed Loop Checkout. RF cables are used to connect the Centaur stage antenna couplers to a coaxial switch box. The RF command signal is carried by coaxial cable from the RSC test set in the blockhouse to the coaxial switch box which is mounted in the service tower. By remote control at the test set, the RF signal is connected to the Centaur stage closed loop system by a coaxial switch in the coaxial switch box. The

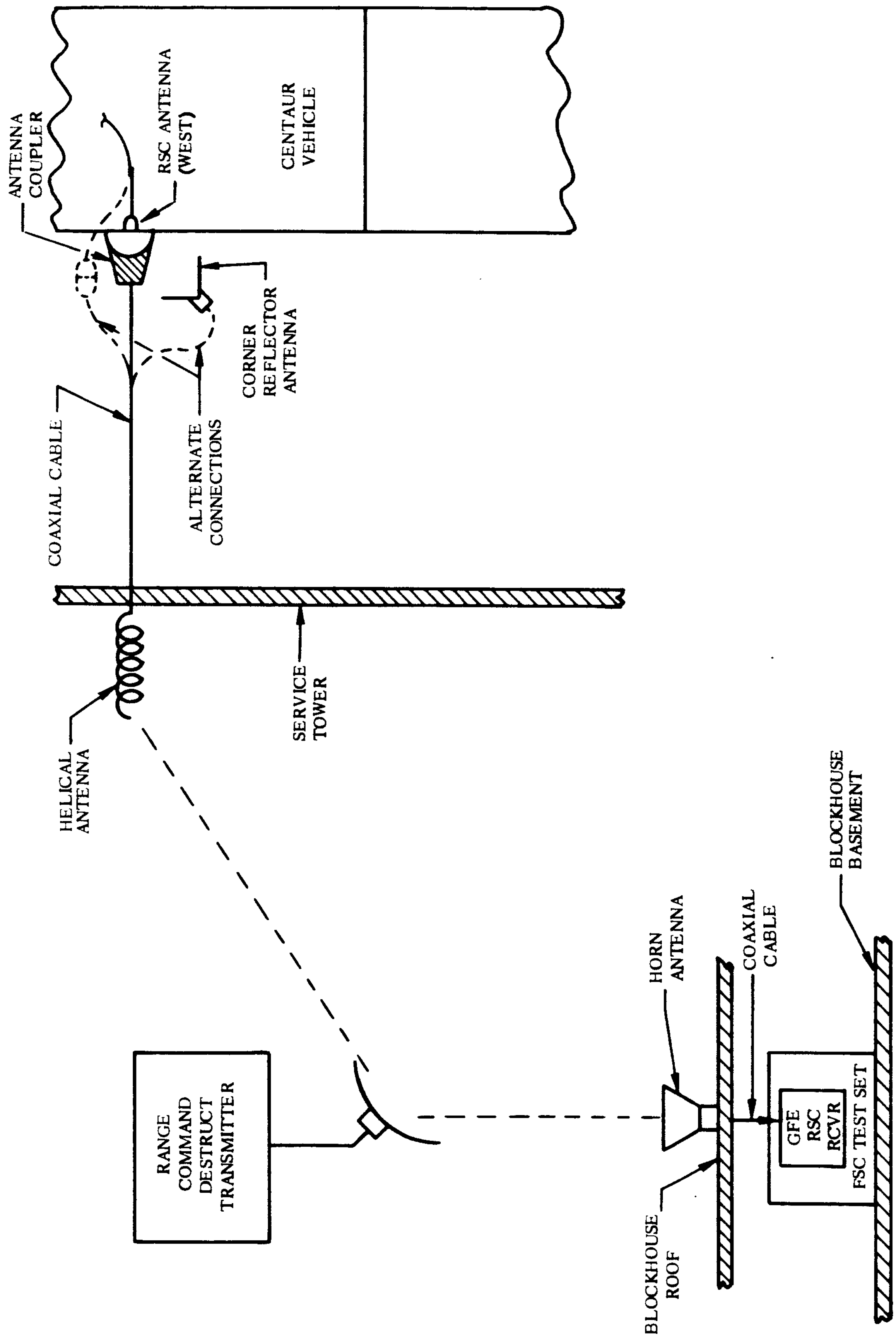


Figure 15.1-5. RSC Checkout System, Open Loop

b. (Continued)
system is controlled by a manual adjustment of the characteristics of the RF command signal at the RSC test set. The closed loop RSC checkout system is shown in Figure 15.1-6. The major components of the closed loop system are as follows:

(1) RSC Test Set, EID 27-5156-5. The function of this test set is to generate an RF signal which is frequency modulated by a specific number and sequence of audio frequency tones for interrogating the vehicleborne RSC receiver. The receiver then responds with 28 vdc outputs which are monitored by the blockhouse launch control. The test set houses a RSC receiver which receives the signals from the range command transmitter via the horn antenna on the blockhouse roof. The test set also selects the launch pad and vehicle antennas to which the interrogation signal is fed. The test set is made up of an RF signal generator, GD/C No. 7-05203-5, a modulation generator, GD/C No. 55-56042-3, and a range safety checkout selector panel. A test set control panel layout is shown in Figure 15.1-7. The test set specifications are presented in Table 15.1-3.

(2) Coaxial Switch Housing, GD/C No. 55-54172. This equipment receives the RF signal from the RSC test set at either one of two coaxial switches. One switch sends the signal to either the Centaur or booster west antenna. The other switch sends the RF signal to either the Centaur or booster east antenna. The coaxial switches are controlled by toggle switches on the control panel of the test set, see Figure 15.1-7. The coaxial switch used is an Amphenol-Borg 327-010562-3, GD/C No. 87-44933-001.

(3) Antenna Coupler, GD/C No. 55-56101.

c. Test Substitution Destruct Box. This equipment is provided as a substitute for the vehicle destructor to demonstrate the capability of the range safety system to fire the destructor upon command. This equipment monitors the destructor circuits for stray voltages and/or currents in excess of positive no-fire values specified during prelaunch operations. This unit (substitution box) contains pyrotechnic simulators, visual indicators, and an arm/safe mechanism. It is mounted on the vehicle in lieu of the destructor box and interconnects with the vehicle destruct circuits.

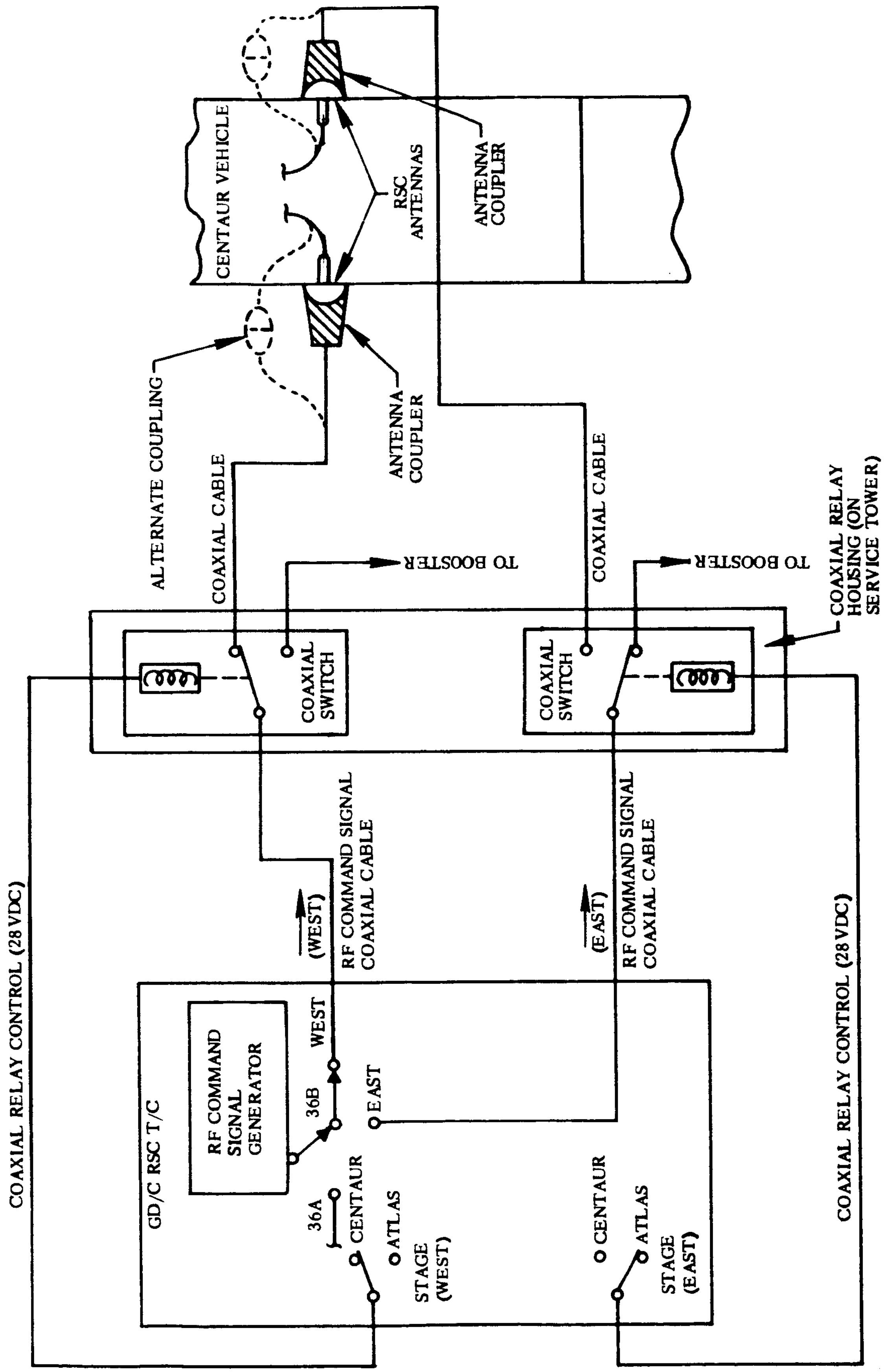


Figure 15.1-6. RSC Checkout System, Closed Loop

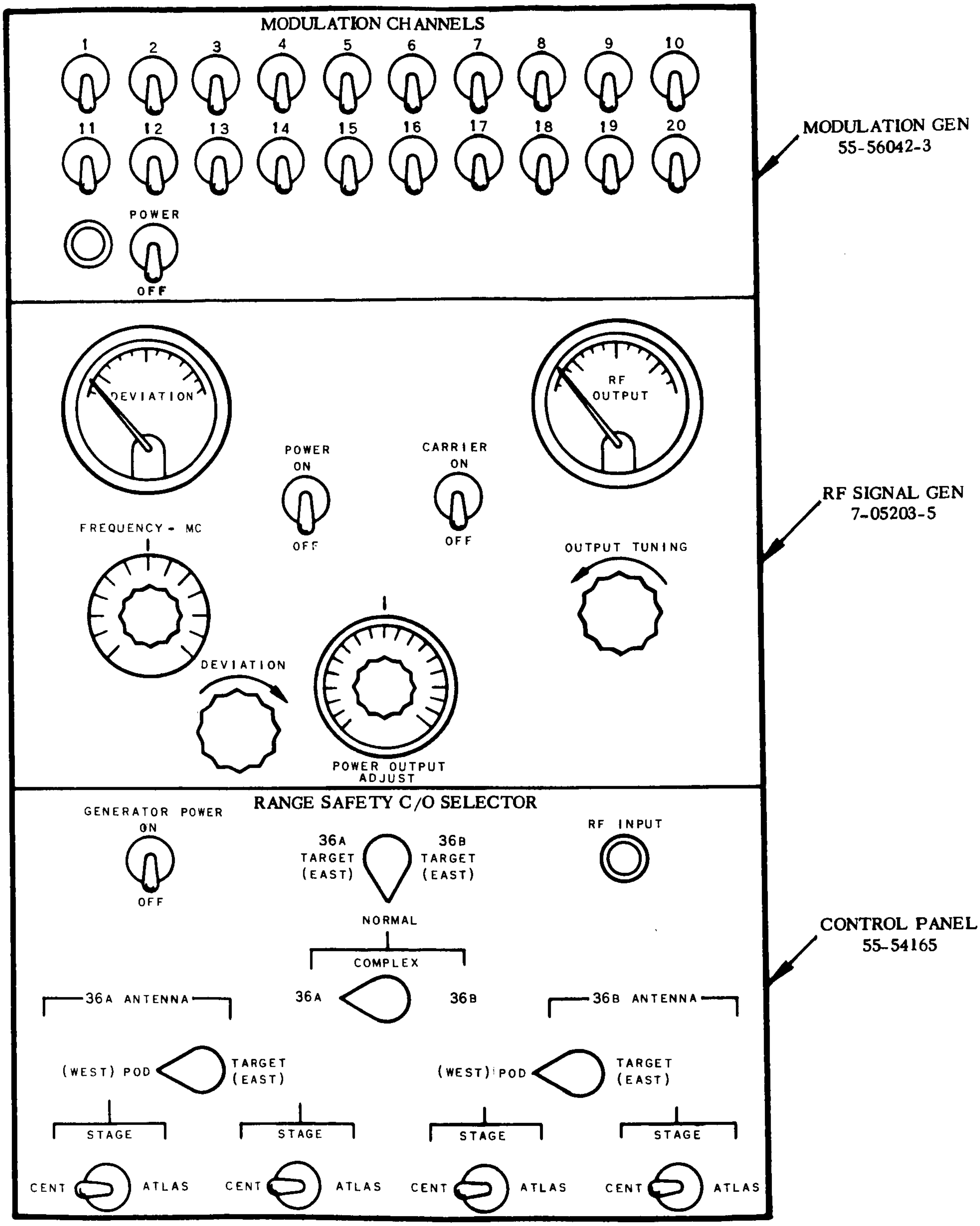


Figure 15.1-7. Front Panel Layout - RSC Test Set

TABLE 15.1-3. SPECIFICATIONS OF TEST SET EID27-5156-5

I ELECTRICAL SPECIFICATIONS

A. OUTPUT RF SIGNAL

1. Carrier Frequency
   Range: 406 to 420 mc in one mc increments.
   Accuracy: ±0.01%.

2. Carrier Power
   Variable
   Range: 1 microvolt to 100,000 microvolts RMS into 50 ohms.
   Accuracy: ± 1 db.

   Fixed
   Amplitude: Not less than 0.75 volt RMS into 50 ohms.

3. Frequency Modulation of the RF carrier
   Range: The first IRIG command tones, individually selectable.
   Accuracy: ± 1 %.
   Amplitude: Continuously adjustable, 0 to not less than 2.0 volts RMS into 500 ohms.
   Deviation of carrier: ± 300 kc maximum.
   Simultaneous Tones: Up to three.

B. RF OUTPUT SWITCHING PANEL

1. Switches the RF output of the test set to either the coaxial cable going to launch Complex 36A or the coaxial cable going to Complex 36B.

2. After 36A or 36B has been selected, the signal can be switched to the east or west side of the vehicle.

3. After east or west has been selected, the signal can be switched to the Atlas (booster) or Centaur RSC antennas.

C. INPUT POWER REQUIREMENTS

1. AC Power
   Voltage: 115 vac ± 10%
   Frequency: 50 to 65 cps
   Phase: Single
   Power: 550 watts.

TABLE 15.1-3. SPECIFICATIONS OF TEST SET EID 27-5156-5 (Continued)

C. INPUT POWER REQUIREMENTS (Continued)

2. DC Power
   Voltage: 28 vdc ± 10%
   Power: 10 watts maximum.

II PHYSICAL SPECIFICATIONS

a. Height: 6 ft
b. Width: 2 ft
c. Depth: 2 ft
d. Weight: 400 lb

15.1.3 CHECKOUT. The RSC checkout test set is functionally tested to verify that it is in a satisfactory operating condition. Verification of satisfactory operating conditions is obtained in accordance with an approved and published procedure at the times specified below:

a. Every 90 days or for each launch vehicle, whichever is the longer.
b. Following any major alteration or repair to the RSC Checkout Set.

Periodic calibrations of the Centaur RSC receiver sensitivity are made to verify satisfactory operating conditions.

15.2 C-BAND RADAR TRANSPONDER SYSTEM

A C-band radar transponder (beacon) is carried on the Centaur vehicle to extend the tracking range of the Eastern Test Range (ETR) radars by transmitting an amplified return signal in response to reception of properly coded radar signals. Ground support equipment (GSE) is provided for the control, monitoring, and checkout of the C-band system during ground operations. Figure 15.2-1 is a block diagram of the telemetry and RF control system.

15.2.1 C-BAND RADAR TRANSPONDER SYSTEM FUNCTION AND CONTROL. The C-band radar transponder provides primary tracking signals from which the in-flight Centaur vehicle position and velocity may be determined as a function of time from launch to a much greater radar range than obtainable from skin tracking alone. This data may be used to provide real time impact predictions to support range safety flight requirements. The vehicleborne system provides omnidirectional coverage and is capable of responding to simultaneous multiple radar interrogation.

When coded RF pulses (interrogations) are received by the transponder from ground radar stations, an RF reply pulse offset to a different frequency is transmitted after a short and fixed delay time. The transponder is then inactive for another fixed time period not exceeding 50 microseconds. The time delay between transmission of the interrogating pulse and receipt of the reply pulse is a measure of the range (distance) between the interrogating radar and the Centaur vehicle (after allowing for the fixed delay).

During ground checkout, the C-band transponder power system is controlled and monitored respectively from a switch and indicator lights on the Telemetry - Second Stage console panel (Figure 16.2-) located in the blockhouse. Ground checkout of the C-band transponder system is made to assure that the vehicle system is operating properly. This checkout is accomplished by interrogating the system and monitoring its reply via one of two test RF coupling methods, open loop or closed loop.

15.2.2 MAJOR COMPONENTS. The C-band radar transponder major components consist of vehicleborne equipment and GSE.

15.2.2.1 Vehicle System. The vehicleborne C-band radar transponder system consists of a transponder, a circulator - duplexer, two antennas, a power divider, and the necessary RF transmission lines. Figure 15.2-2 is a block diagram of the vehicle C-band radar transponder system.

15.2.2.2 Ground Support Equipment. The GSE consists of a power control console and associated relay logic for energizing the vehicle C-band radar transponder system and test system equipment for checkout of the system.

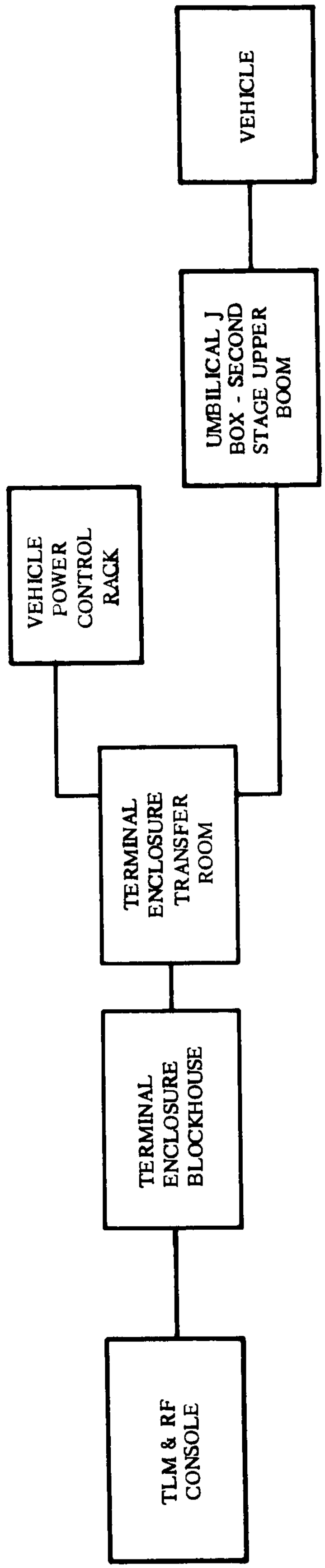


Figure 15.2-1. Block Diagram - TLM and RF Control System, Centaur

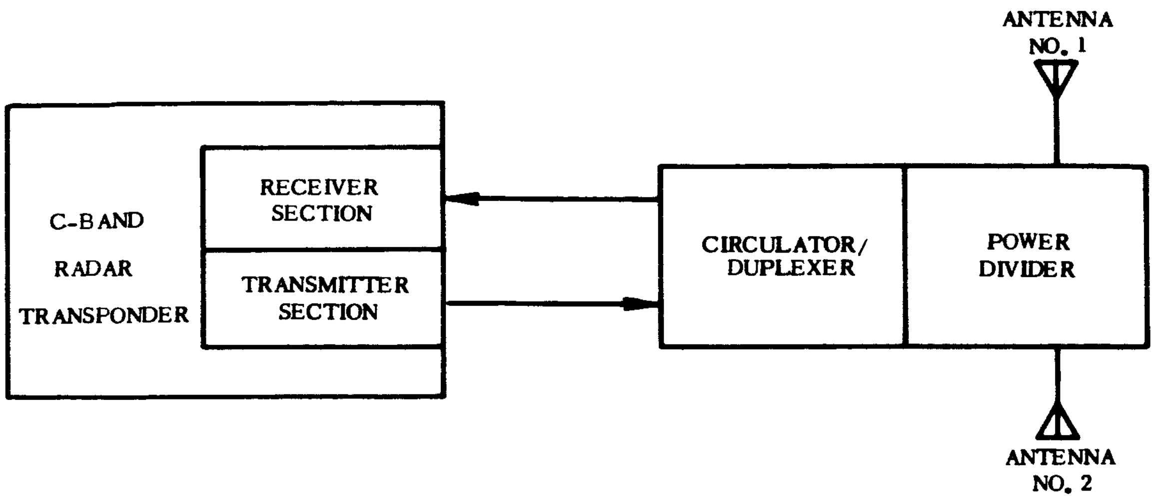


Figure 15.2-2. Block Diagram - Centaur C-Band Radar Transponder System

15.2.2.2.1 Power Control. The 28 vdc power supplied to the vehicle C-band radar transponder from the ground source is controlled by the "C" BAND ON/OFF switch located on the TLM & RF console, see Figures 15.2-1 and 16.2-2. An elementary schematic is shown in GD/C drawing 55-98072.

15.2.2.2.2 Test System. The C-band transponder (Beacon) test system consists of equipment used to assure that the vehicleborne system is operating properly by interrogating the system and monitoring its reply via one of two test coupling methods, open loop (soft-link) and closed loop (hard-link).

a. Open Loop Method. The open loop or "soft link" coupling method, Figure 15.2-3, uses the actual C-band range transmitter-receiver to interrogate, and monitor the reply signal of, the vehicleborne C-band radar transponder system. The system is controlled by a manual adjustment of the RF interrogating pulse characteristics at the range transmitter. The components of this coupling method are: Two parabolic type antennas, GD/C No. 80-09901-002, a 3/8 inch diameter semiflexible coaxial cable; and a flexible coaxial cable, type RG-225/U.

b. Closed Loop Method. The closed loop or "hard-link" coupling method, Figure 15.2-4, uses the GD/C test set (EID 55-5593) to interrogate, and monitor the reply of, the vehicleborne C-band transponder system. The test set is mounted on a platform of the service tower and connected (coupled) to the vehicle as shown in the figure. The system is controlled by a manual adjustment of the RF interrogating pulse characteristics at the test set. The components of this coupling method are as follows:

(1) C-band RF Signal Generator. This generator, GD/C No. 55-05351-1, supplies the RF pulse train required to properly interrogate the C-band transponder so that it will transmit a reply pulse. Both the test set interrogating pulse train and the transponder reply pulse are detected by the same crystal

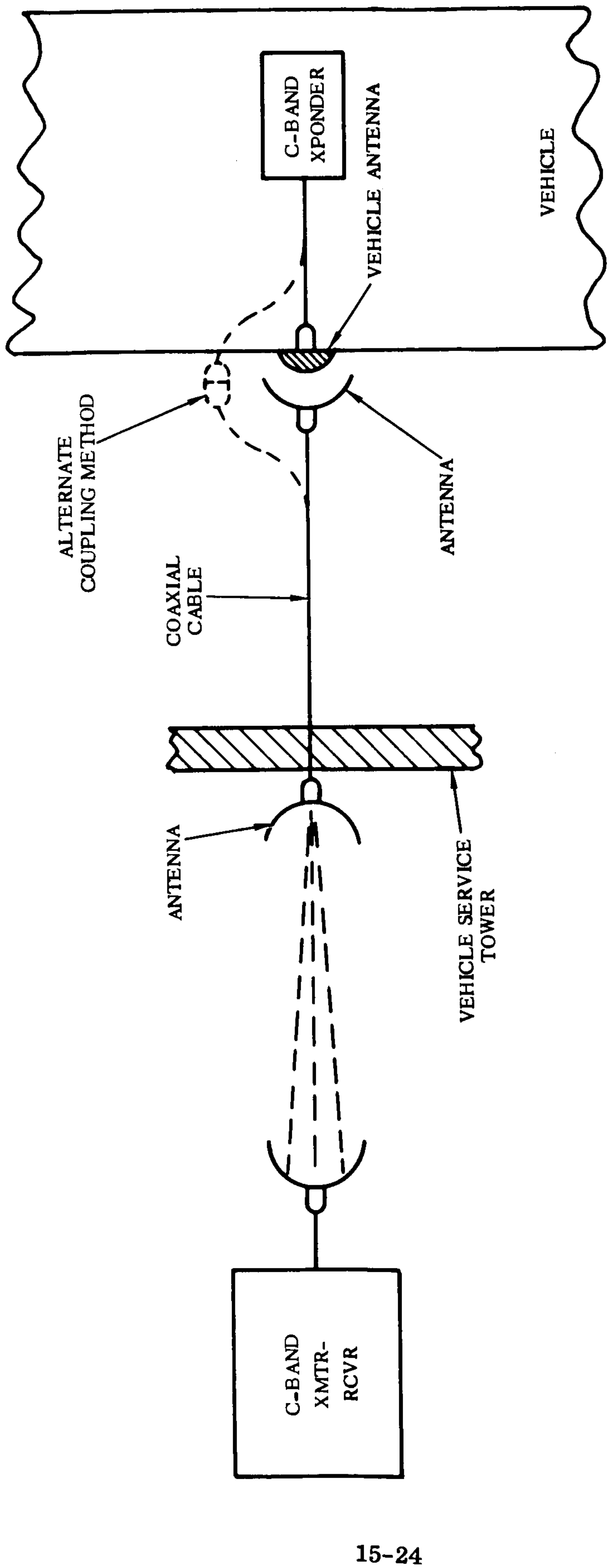


Figure 15.2-3. C-Band Beacon RF Coupling - Open Loop

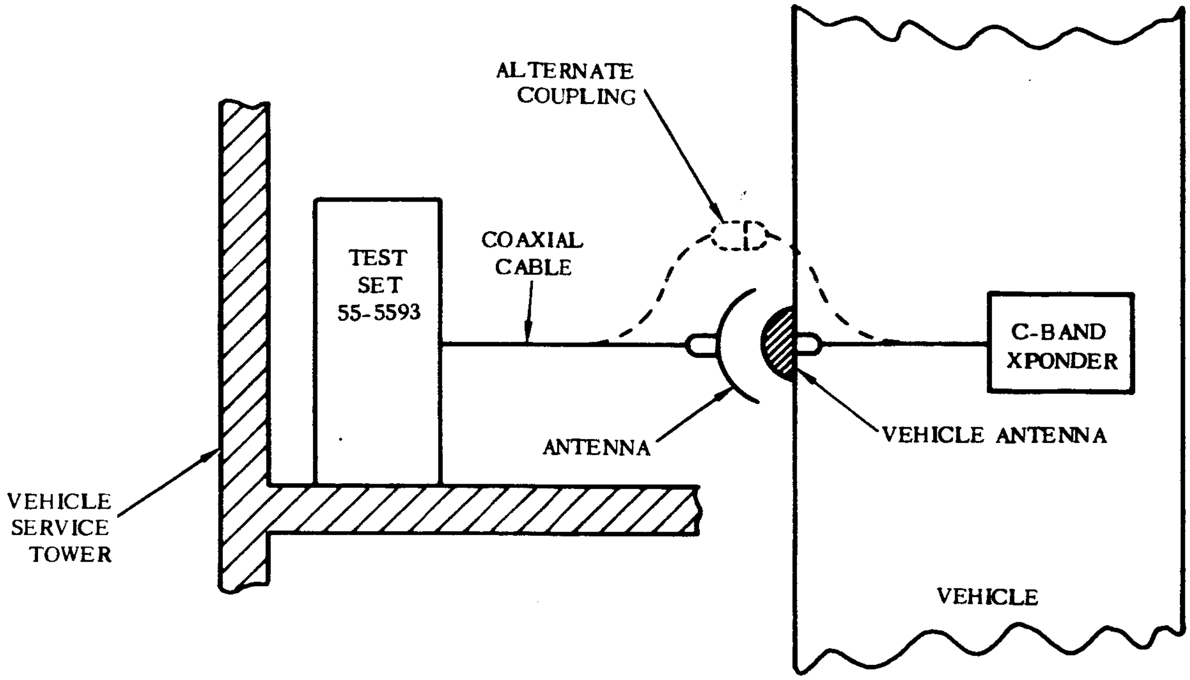


Figure 15.2-4. C-Band Beacon RF Coupling - Closed Loop

detector in the signal generator and displayed as a single trace on the test set oscilloscope. A built-in frequency meter dips the displayed pulse for a coarse resolution of the frequency and moves the pointer of an ammeter for a fine resolution. An attenuator is used to vary the power of the interrogating pulses and is equipped with a calibrated dial to indicate peak pulse power. An attenuator is also used to vary the power of the reply pulses and is equipped with a dial calibrated to indicate peak reply pulse power. The RF reply pulses are separated from the interrogating pulses and applied to individual output jacks for monitoring purposes.

(2) Oscilloscope. This oscilloscope, GD/C No. 55-05349-1, displays the single trace display generated in the C-band RF signal generator showing both the interrogating pulse train and the transponder reply pulse. The characteristics of the reply pulse and its time relationship with the interrogating pulse train are measured directly from the scope trace. The frequency of either pulse is measured by adjusting the above mentioned frequency meter for the point of maximum dip of the pulse and maximum deflection of the ammeter. The peak power of the transponder reply pulse is measured by adjusting the attenuator controlling the reply pulse amplitude so that the height of the reply pulse matches the height of the interrogating pulse, then reading the attenuator dial.

(3) Counter. The counter, GD/C No. 55-05320-1, counts and gives a direct readout of the repetition frequency of the transponder reply pulse. The counter is triggered by the detected output of the RF reply pulse monitoring jack on the signal generator.

(4) Monitor Panel. The monitor panel, GD/C No. 55-54117-1, serves as the interconnection point between the d-c power supply of the test set and the C-band transponder. It is used during bench testing of the transponder as the means of supply of d-c power to the transponder. A cable completes the hard link, one end connecting to a jack on the monitor panel, and the other end connecting to the d-c power input jack on the transponder.

(5) DC Power Supply. This 28 vdc power supply, GD/C No. 55-05350-1, supplies the d-c power for the transponder during bench testing.

(6) Antenna. The parabolic antenna, GD/C No. 80-09901-002, acts as a link in the system which couples the signals between the test set and the vehicle-borne C-band transponder antenna. This antenna is the same as used in the open loop or "soft link" coupling method.

(7) Coxial Cable, Semiflexible. This cable carries the signal between the antenna and the test set. This cable is also used in the open loop coupling method.

(8) Coaxial Cable, Flexible. This cable, No. RG-225/U, is used as a jumper cable between the semiflexible coaxial cable and the antenna and test set.

A tabulation of the major capabilities of the test set are presented in Table 15.2.1.

TABLE 15.2-1. C-BAND RADAR TRANSPONDER TEST SET CAPABILITIES (EID 55-5593)

Characteristic	Description
Output Frequency	Continuously tunable, 5350 to 5950 MCPS.
Output Power	+10 to -100 DBM peak pulse. An additional 30 db can be achieved by feeding the output of the signal generator through the microwave amplifier.
Frequency Monitor	Direct reading 5350 to 5950 MCPS. Measures both interrogation from test set and reply from transponder.

TABLE 15.2-1. C-BAND RADAR TRANSPONDER TEST SET CAPABILITIES (EID 55-5593) (Continued)

Characteristic	Description
Power Monitor	Direct reading peak pulse power from +30 DBM to +70 DBM. A 40 db increase in sensitivity can be achieved by feeding the input signal through the microwave amplifier before it is applied to the power monitor circuitry.
Pulse Modulation	Single or double pulse output, selectable on the front panel.
Pulse Repetition Frequency	Continuously adjustable between stops from 5 to 5000 ± 1 pulse per second.
Repeat Group Delay	Continuously adjustable, 40 to 150 microseconds, ±3% of scope sweep setting.
DC Power Supply	Volts, 0-36; Amps, 0-5; Impedance, 4 milliohms (dc to 1 kc).
AC Power Input	Voltage, 105 to 125 vac (Phase to neutral); Frequency, 60 cps; three phase.
Physical Specifications	Height, 5 1/2 feet; width, 4 feet; depth 2 1/2 feet; weight, 700 pounds.

15.2.3 CHECKOUT. The C-band transponder (beacon) test set is functionally tested to check power output and to demonstrate the test set ability to interrogate a test transponder. Verification of a satisfactory operating condition is obtained prior to checkout of the launch vehicle C-band transponder. The functional test is made according to an approved and published procedure.

A block diagram of the C-band transponder test set validation setup is shown in Figure 15.2-5. A functional description of the test set operating controls and connectors is given in Table 15.2-2.

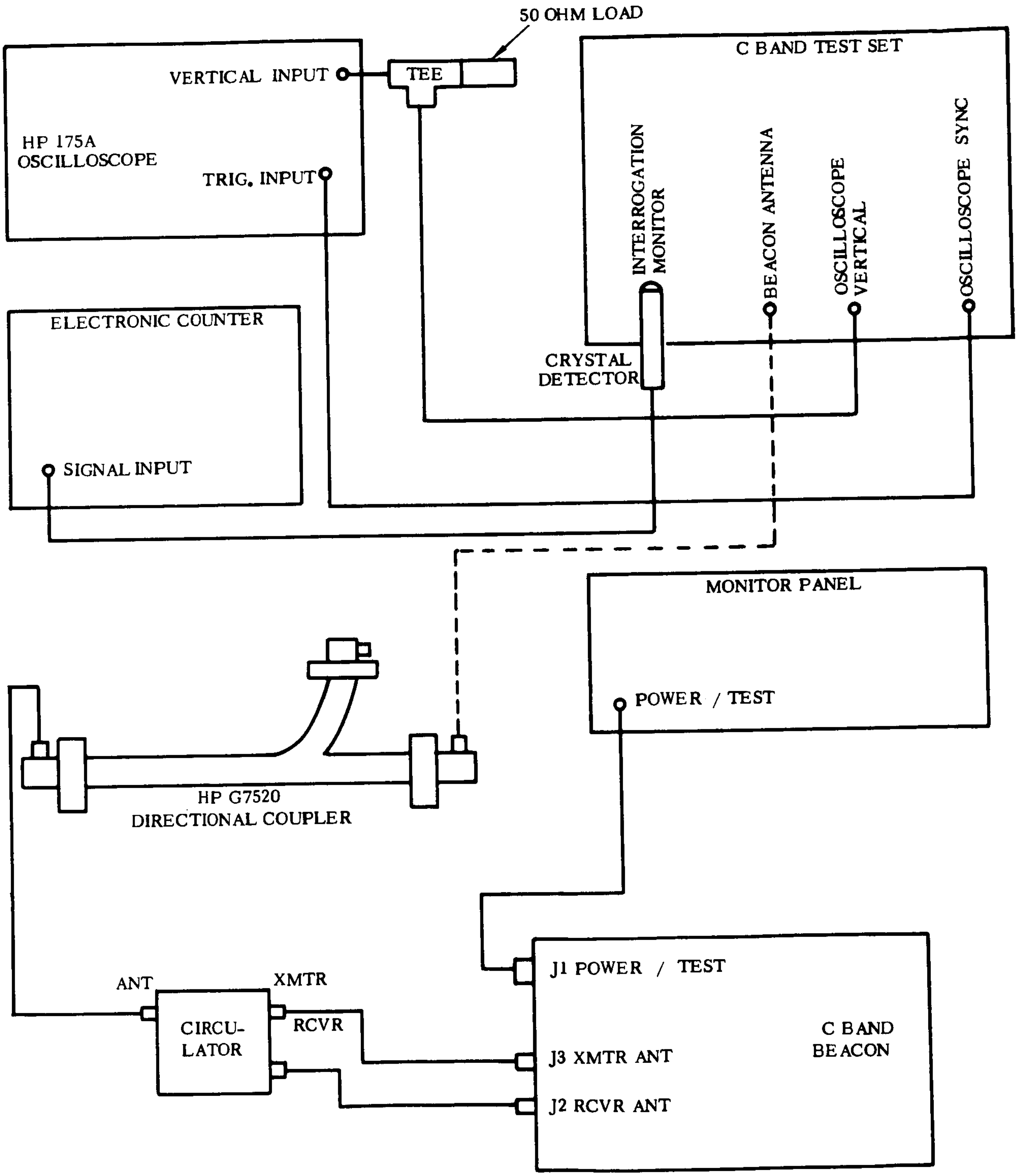


Figure 15.2-5. C-Band Radar Transponder Test Validation Setup

TABLE 15.2-2. FUNCTIONAL DESCRIPTION OF OPERATING CONTROLS AND CONNECTORS, C-BAND RADAR TRANSPONDER TEST SET, EID 55-5593

Controls and Connectors	Description
POWER	Primary power switch. Indicator alongside illuminates to indicate AC power is applied.
STANDBY - OPERATE	Standby switch. Indicator alongside indicates standby operation.
BEACON ANTENNA	Connection to antenna jack of C-band beacon (transponder).
OSCILLOSCOPE VERTICAL	Crystal detector output. Shows both interrogate and reply pulse groups. Line is terminated by 470 ohms in test set.
EXT TRIG POLARITY	External synchronization connection chooses either positive or negative polarity external sync pulse.
OSCILLOSCOPE SYNC	Synchronization trigger for oscilloscope.
INTERNAL MONITOR	Power meter. Indicates calibrated RF output of test set measured on thermistor bridge.
INTERNAL MONITOR	Frequency meter. Indicates output of frequency meter tuned for peak reading.
POWER OUTPUT ZERO	Power monitor bridge balance control.
POWER OUTPUT LEVEL SET	Adjusts RF output for calibrated condition.
FREQUENCY METER	Absorption frequency meter for indicating frequency of interrogate or reply pulses by dip in oscilloscope display and meter reading.
FREQUENCY METER AMPLIFIER	Varies sensitivity of wavemeter amplifier.

TABLE 15.2-2. FUNCTIONAL DESCRIPTION OF OPERATING CONTROLS AND CONNECTORS, C-BAND RADAR TRANSPONDER TEST SET, EID 55-5593 (Continued)

Controls and Connectors	Description
RECEIVER SENSITIVITY - DBM	RF input attenuator, marked for actual peak power output.
BEACON POWER + DBM	RF input attenuator, marked for actual peak power input when compared against calibrated output.
OUTPUT FREQUENCY	Adjusts internal RF oscillator frequency.
FUNCTION SELECTOR - CALIBRATE	Selects calibrated repetition rate and pulse group for setting RF output.
FUNCTION SELECTOR - EXT TRIG	Disables internal repetition rate generator for external triggering of pulses. Also used as zero set position.
FUNCTION SELECTOR - INT TRIG	Internal repetition rate generator activated.
INTERNAL RATE SELECTOR	Selects PRF range for normal and repeat group relay.
REPETITION CONTROL RATE	Varies PRF of internal rate generator.
REPEAT GROUP DELAY	Varies spacing between successive pulse groups.
P2 DELAY VARIABLE	Varies P2 time position relative to P1.
P2 DELAY SELECTOR	Varies P2 time position relative to P1 in fixed pre-set increments.
P2 DELAY DEVIATION	Deviates P2 spacing about fixed position.
P1 WIDTH	Varies width of P1.
P2 WIDTH	Varies width of P2.

TABLE 15.2-2. FUNCTIONAL DESCRIPTION OF OPERATING CONTROLS AND CONNECTORS, C-BAND RADAR TRANSPONDER TEST SET, EID 55-5593 (Continued)

Controls and Connectors	Description
INTERROGATION MONITOR	RF output of interrogation from test set for counter.
REPLY MONITOR	RF output of beacon reply for counter.
REPLY MONITOR LEVEL	Attenuates output of reply monitor.

SECTION XVI

TELEMETRY SYSTEM

16.1 TELEMETRY SYSTEM FUNCTION AND CONTROL

The Centaur vehicle Telemetry system receives, conditions, and relays vehicle systems performance data to ground recording and monitoring equipment by use of RF transmissions. During ground operations, the Telemetry system operates in conjunction with telemetry checkout equipment. Ground Support Equipment (GSE) is provided for control and monitoring of the Telemetry system, including energizing the system, controlling the commutators, and providing a telemetry "Ready" signal. Figure 16.1-1 is a block diagram of the Telemetry Ground Control system.

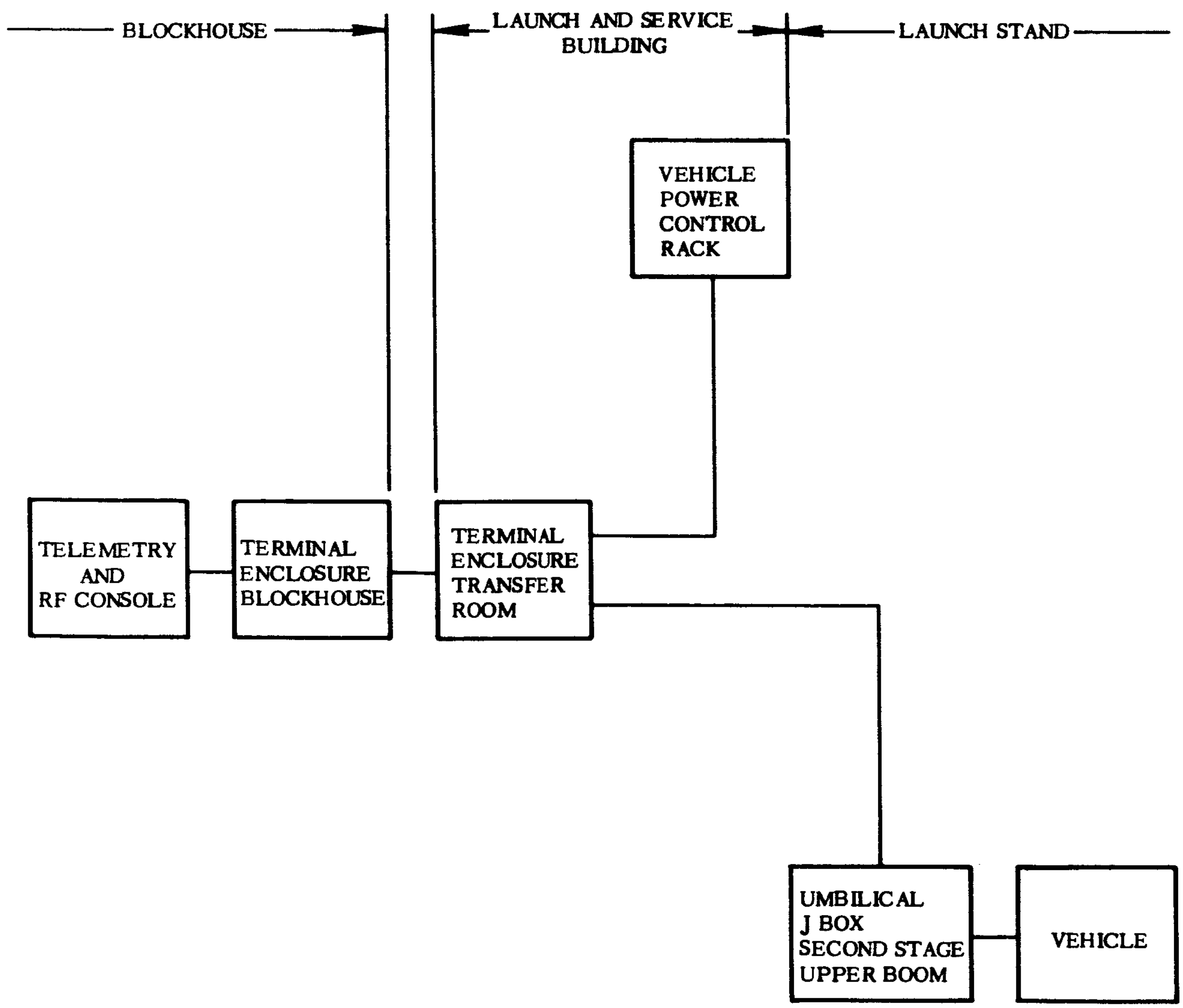


Figure 16.1-1. Centaur Telemetry and RF Control System Block Diagram

16.2 TELEMETRY SYSTEM MAJOR COMPONENTS

16.2.1 VEHICLE SYSTEM. The vehicleborne system consists of one telepak and one antenna with associated wiring and connectors. The telepak contains a signal conditioning section and an RF section. The signal conditioning section consists of conversion circuitry, power supply, calibrator, commutators, and subcarrier oscillators. The RF section contains the telemeter transmitter.

The system transmits eighteen Inter-Range Instrumentation Group (IRIG) channels of calibrated data. The telepak signal conditions incoming analog or digital data as required to make it compatible with continuous or time-multiplexed information channels. The conditioned signals (normally 0 to 5 vdc) modulate the voltage-controlled subcarrier oscillators, which in turn frequency modulate the RF signal. The transmitter is directly coupled to the transmitting antenna. The system operates on 28 vdc power supplied through an internal/external motorized relay (changeover switch) from GSE prior to launch, and supplied from the vehicle electrical system during flight. Figure 16.2-1 is a block diagram of the telepak showing the signal-flow of various instrumentation signals.

16.2.2 GROUND CONTROL AND MONITORING EQUIPMENT. The ground power control and monitoring console assembly for the Telemetry system is located in the blockhouse. The relay logic chassis is located in the transfer room of the Launch and Service building. The control panel of the Telemetry - Second Stage console assembly is presented in Figure 16.2-2. In addition to TLM 1 and C-Band power controls, there are provisions on the panel for AZUSA system controls and a POWER TRANSFER switch. This transfer switch will be used to provide for control of a separate telemetry battery as required for a two-burn mission capability. In addition, a timer will be provided for the separate battery to indicate operating time. All telemetry ground power is controlled by a single switch and monitored by a single indicator light. The necessary power supplies, control relays, and circuit breakers are part of the Facility Power system (see Figure 16.2-3). Elementary schematics of the RF system, 2nd Stage, and the Telemetry system, 2nd Stage, are presented in General Dynamics Convair (GDC) drawings 55-98038 and 55-98072, respectively.

Functional descriptions of the switches and indicators on the Telemetry - Second Stage console panel are presented in Table 16.2-1. The telemetry ground control and vehicleborne system interfaces are listed in Table 16.2-2.

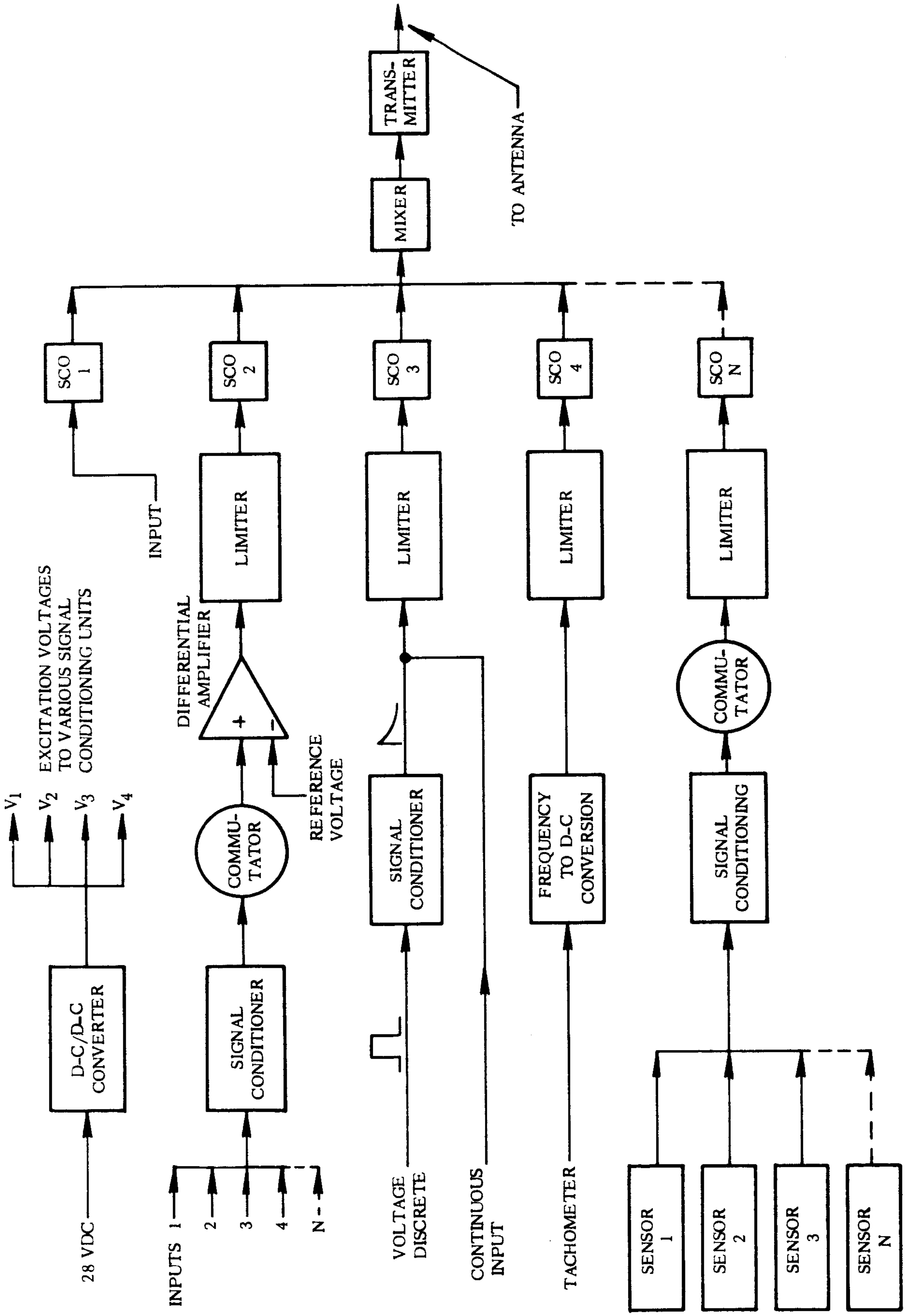


Figure 16.2-1. Telepak Block Diagram

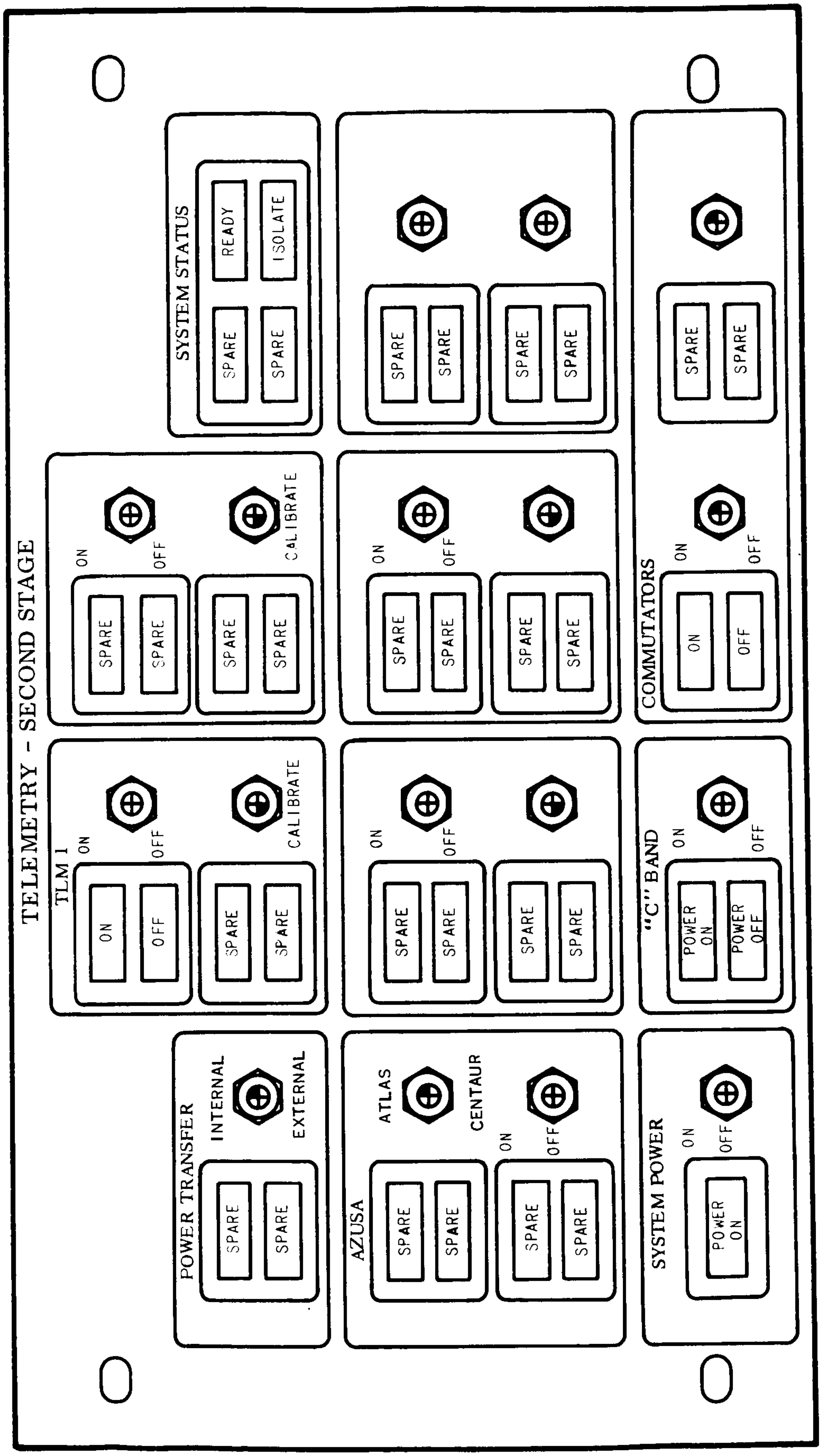


Figure 16.2-2. Telemetry and RF System Control Console Panel

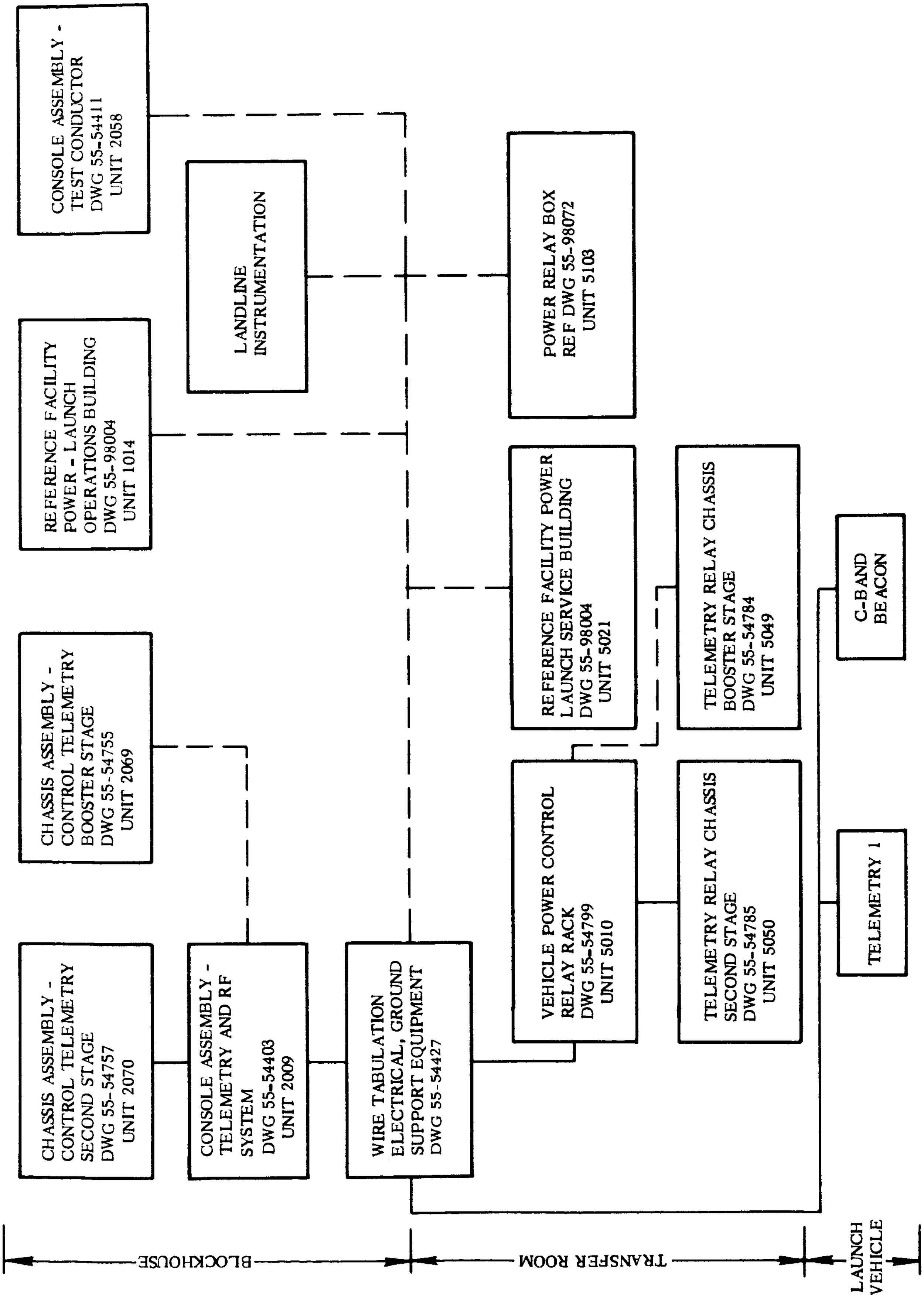


Figure 16. 2-3. Second Stage Telemetry Control System GSE Block Diagram

TABLE 16.2-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND LIGHTS ON SECOND STAGE TELEMETRY CONTROL PANEL

CONTROL OR INDICATOR	FUNCTION
SYSTEM POWER switch	This switch is used to activate the control bus in the control panel and in the relay chassis. It activates relays in the Facility Power system which make up part of the SYSTEM POWER ON permit circuit.
TELEMETRY 1 ON/OFF switch	This is a momentary on-off switch that operates a latching relay on the vehicle to apply or remove 28 vdc power used to turn the Telemetry system on or off.
COMMUTATORS ON/OFF switch	This switch, in the OFF position, provides a 28 vdc power signal to maintain the commutators off. In the ON position, the power signal is removed and the commutators operate.
TELEMETRY 1 CALIBRATE switch	This pushbutton switch provides a 28 vdc signal by which to calibrate the Telemetry system.
C-BAND ON/OFF switch	This switch is used to apply 28 vdc to the vehicle to operate the C-Band Beacon system.
SYSTEM POWER ON indicator	This light illuminates when the system power switch is activated to ON.
TELEMETRY 1 ON/OFF indicators	These lights illuminate whenever the system power switch is ON and indicate the last command sent by the TLM 1 ON/OFF switch to the Telemetry system. They are locked on by a latching relay.
COMMUTATORS ON/OFF indicators	These lights illuminate according to the position of the COMMUTATORS ON/OFF switch and indicate the status of the commutators.
C-BAND POWER ON/POWER OFF indicators	These lights illuminate according to the position of the C-Band ON/OFF switch and indicate POWER ON or POWER OFF.
SYSTEM STATUS READY indicator	This indicator light illuminates when the Telemetry system ready ladder is complete. To complete the ready ladder, it is necessary that SYSTEM POWER be ON, COMMUTATORS

TABLE 16.2-1. FUNCTIONAL DESCRIPTION OF SWITCHES AND LIGHTS ON SECOND STAGE TELEMETRY CONTROL PANEL (Continued)

CONTROL OR INDICATOR	FUNCTION
	be ON, C-BAND power be ON, TLM 1 be ON, and vehicle power be on internal. A TLM READY signal is also sent to the Test Conductor system as a part of the Test Conductor ready ladder (see Section 12.2).
SYSTEM STATUS ISOLATE indicator	This indicator light illuminates when the Telemetry system ready ladder is complete and indicates that all ground power is removed from the vehicle to ensure that the vehicle is completely on internal power and isolated.

TABLE 16.2-2. TELEMETRY GSE/VEHICLE SYSTEM INTERFACES

ITEM	INTERFACE
SIGNALS RECORDED BY LANDLINE INSTRUMENTATION	a. C-Band electrical current b. C-Band electrical power on c. Telemetry 1 electrical current d. Telemetry 1 off e. Telemetry 1 commutators on
28 VDC FACILITY POWER	28 vdc facility power is received from circuit breakers located in facility power chassis units 1014 and 5021.
GROUND RETURN	D-c ground return is interconnected with booster stage telemetry units and booster stage vehicle power.
TELEMETRY READY	A second stage telemetry ready signal is sent to the Test Conductor's Console.

16.3 TELEMETRY CHECKOUT

A telemetry ground station is provided for both open- and closed-loop checkout of the Centaur vehicle Telemetry system. This equipment (which is government furnished) receives, detects, decommutates, records, and displays signals from the vehicle Telemetry system for the purpose of checking out the system after the vehicle has been erected on the launch pad.

16.3.1 TELEMETRY GROUND STATION FUNCTION. The double- and triple-modulated signal enters the ground station (see Figure 16.3-1) through the antenna switch which selects either the open-loop or closed-loop signals. The signal is then fed into the multicoupler which parallel-feeds the signal to 8 receivers simultaneously. Each receiver is tuned to a separate telemetry carrier frequency, enabling the ground station to receive as many as eight different transmissions at once. Within each receiver, the signal is amplified and the composite subcarrier signal is separated (detected) from the carrier signal through a discriminator network and filter. This composite signal (commonly called the "subcarrier multiplex" or "video signal") is a replica of the signal used to modulate the telemetry transmitter.

The multiplexed signal is then routed to a bank of subcarrier discriminators and to a magnetic tape recorder. Each discriminator accepts only that particular subcarrier frequency which its band pass filter is designed to pass. The output signals of the discriminators are proportional to the signals used to modulate the subcarrier oscillators in the vehicleborne system. Some of these signals are commutated; some are continuous.

The commutated signals are fed to a parallel bank of switches, or "gates," each of which is closed for a short period. These closures occur in a cyclic order so that only one gate is closed at any one instant. The gate closures are precisely synchronized in time with the pulses applied to their common inputs so that each gate delivers the output pulses associated with one particular commutation channel. The outputs of the gates are then fed to the separate channels of the strip chart recorders, as are the continuous discriminator outputs.

The panadaptor is used to monitor the intermediate frequency (IF) signals of the receivers. It has an oscilloscope display with amplitude on the vertical and frequency on the horizontal axis. This type of presentation allows operators to determine the number and relative strength of signals in a portion of the telemetry band, the nature of interfering signals, the type of modulation on the signals, and many other kinds of information. The time base can be contracted to spread out an individual signal or expanded to include all signals in a segment several megacycles wide.

The gate monitors give a meter display of the gate outputs for real-time monitoring.

The telemetering indicator and 3-point calibrator are used to check the Telemetry system operation and subcarrier deviation limits.

Typical characteristics of the telemetry ground station major components are presented in Table 16.3-1.

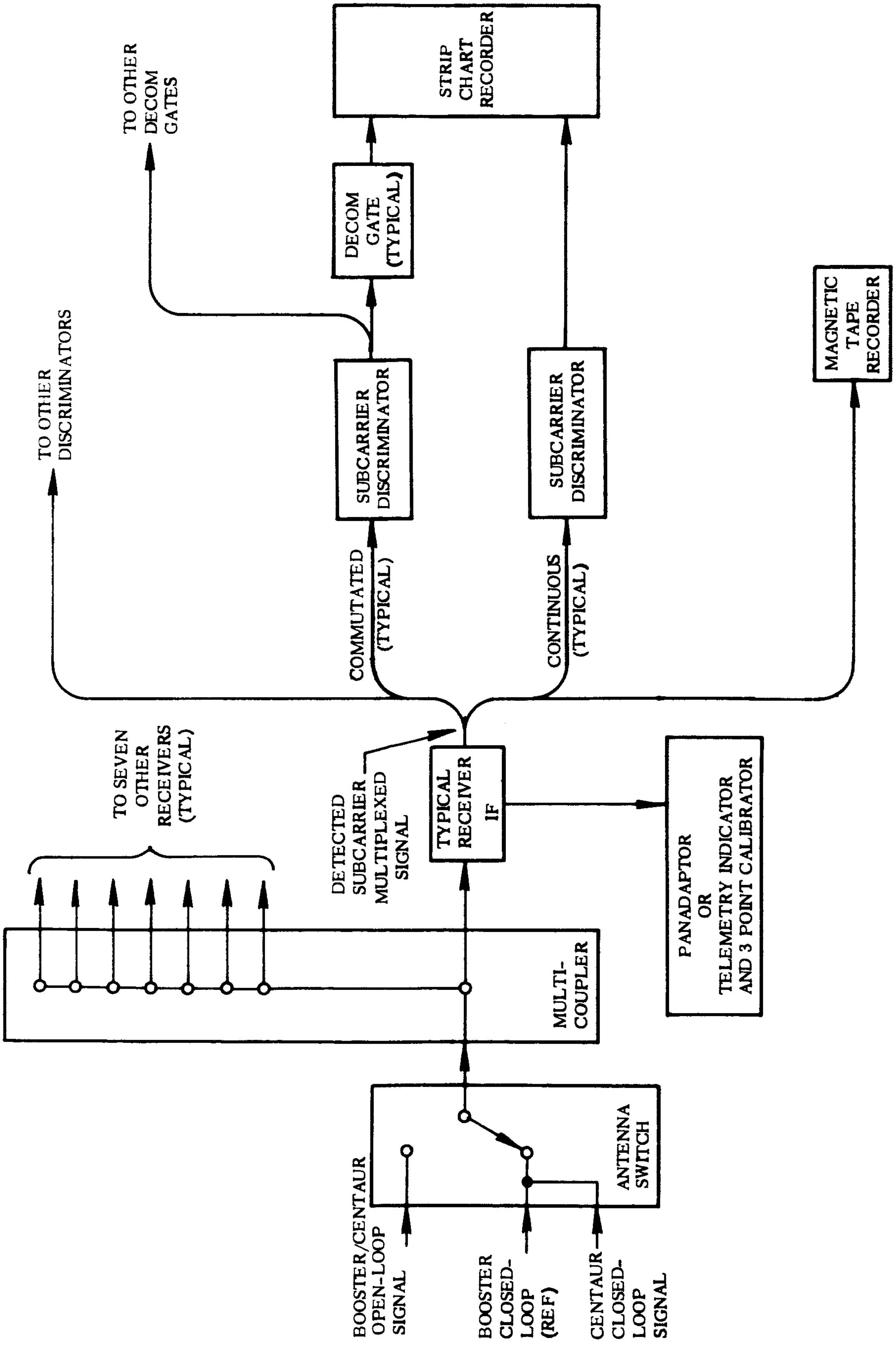


Figure 16.3-1. Telemetry Ground Station, Complex 36 Blockhouse

TABLE 16.3-1. TYPICAL CHARACTERISTICS, TELEMETRY GROUND STATION MAJOR COMPONENTS

ANTENNA SWITCH	
VSWR	1.1 to 1
Crosstalk	60 decibels down
MULTICOUPLER	
Pass Band	215 to 260 megacycles
Uniformity of Response	Within 1 decibel
Gain	Approximately unity
Impedance	Designed to operate in 50 ohm system
Receiver Outputs	8
RECEIVER	
Tuning Range	55 to 260 megacycles
Sensitivity	4 microvolts produce at least 23 decibels signal-to-noise ratio, with 100 kilocycle deviation, 1 kilocycle modulation frequency.
Outputs Provided	a. Wideband video signal for supplying high impedance load b. Speaker, headphones, or 600 ohm balanced output for external use c. 1 megacycle IF signal, low impedance, approximately 1 volt with 1 millivolt input d. 21.4 megacycle IF signal, low impedance, approximately 1 volt with 1 millivolt input e. High impedance, direct-coupled video, approximately 150 vdc for On-frequency, continuous wave signal.
Video Output on FM	140 millivolts per kilocycle (approx)
FM Output Stability	Varies less than 2 decibels for inputs above 1 microvolt
Video Amplifier Response	10 cps to 300 kilocycles within 3 decibels.
PANADAPTER	
For Receivers with IF	21.4 megacycles
Sweep Width	0 - 30 megacycles
Direct Sensitivity (maximum voltage at the center frequency required for 1/4-inch deflection)	50 microvolts

TABLE 16.3-1. TYPICAL CHARACTERISTICS, TELEMETRY GROUND STATION MAJOR COMPONENTS (Continued)

PANADAPTER (Continued)	
Sweep Rate	30 sweeps per second, line synchronized
Amplitude Scales	Nominally linear
Resolution Capabilities	25 kilocycles at maximum sweep width, approximately 20 percent of full sweep.
SUBCARRIER DISCRIMINATOR	
Frequencies	Any center frequency in the range from 400 cps to 70 kilocycles
Subcarrier Frequency Deviation	±7.5 percent and ±15 percent are standard
Intelligence Frequency	IRIG bandwidths are standard
Rejection of Unwanted Signals.	Discriminator response is negligible to modulation appearing on spurious co-channel subcarrier signals. These are signals appearing at the band pass input filter whose amplitude is not more than 90 percent of that of the desired subcarrier
Time Delay of Input Filter	With a ±7.5 percent deviation, delay is equivalent to approximately 4 cycles of subcarrier center frequency. With a ±15 percent deviation, delay is 2 cycles of subcarrier frequency.
Input Impedance	0.5 megohms shunted by approximately 20 mmfarad
Input Range	10 millivolts minimum. Dynamic range for any input level setting is 30 decibels
Output	Single-ended and referred to ground. The output for design deviation is continuously variable from ±6.6 volts to ±90 volts, with a maximum of ±25 milliamperes. The output impedance is less than 10 ohms
Linearity of Output vs Subcarrier Frequency	±0.1 percent of full bandwidth based on best straight line
Output Response vs Intelligence Frequency	Flat within ±0.5 decibel as a function of the standard low pass output filter. An output filter with Gaussian characteristics is used where commutated or step function data is to be handled

TABLE 16.3-1. TYPICAL CHARACTERISTICS, TELEMETRY GROUND STATION MAJOR COMPONENTS (Continued)

SUBCARRIER DISCRIMINATOR (Continued)	
Output Stability	±0.5 percent of full bandwidth in a 15 hour period after a 15 minute warm-up
Sensitivity Stability	±0.25 percent of bandwidth.
DECOMMUTATOR GATE	
Input Signal	0.5 to 60 volts peak-to-peak with pulse rate from 1 to 5,000 pps, single-ended or double-ended, positive or negative
Input Impedance	Not less than 100,000 ohms
Input Signal-to-Noise Ratio	Not less than 1.2:1 (peak-to-peak symmetrical noise)
Synchronization	Will maintain synchronization with not more than ±25 percent variation in commutation rate, with a rate of change not more than 5 percent per frame
Number of Gates	Conforms to a quantity specified by IRIG standards, including Numbers 18, 30, 45, 60, and 90
Output Characteristics	Each gate provides the following output signals for separate or simultaneous use: a. Oscillograph output: Range adjustment from minus (-) 5 to plus (+) 5 milliamperes, through zero to 10 milliamperes into a 330 ohm load (auxiliary line driver units increase the output current to 25 milliamperes with an output impedance of 0.05 ohm) b. Pen Amplifier Drive: Supplies zero to 10 vdc to drive accessory pen recorder amplifiers (high impedance) c. Meter Output: Supplies zero to 10 vdc to drive accessory meters (high impedance) d. Digital Output: 8 bit parallel output provides for real time digital readout

TABLE 16.3-1. TYPICAL CHARACTERISTICS, TELEMETRY GROUND STATION MAJOR COMPONENTS (Continued)

DECOMMUTATOR GATE (Continued)	
Missing Pulses	The system maintains normal synchronization with not more than 15 consecutive missing pulses on the input signal
Cross-Strapping	Individual channels are capable of cross-strapping for the purpose of increasing frequency response
Slope-Off	The output signal from any channel does not have measurable slope-off
Linearity	The system linearity is within one-half percent of full scale
Adjacent Channel Cross-talk	Less than 0.1 percent of full scale.
STRIP CHART RECORDER	
Paper Speeds	0.25, 0.5, 1, 2.5, 5, 10, 25, 50, and 100 mm/second
Event Marker	Right margin - built-in timer provides 1 second timing marks. A provision is made for manual or remote event marking from an external control source
Paper Length	Standard roll is 200 feet long. An adapter allows use of 1,000 foot rolls
Medium Gain Amplifier	a. Maximum Sensitivity: 0.5 millivolts/division b. Attenuation Range: 0.5, 1, 2, 5, 10, and 20 millivolts/division; 0.5, 1, 2, 5, 10, and 20 volts/10 divisions. Attenuator error ± 2 percent c. Input Circuit: 0.5 megohm on millivolt ranges, 1 megohm on volt ranges. Input is floating and guarded from chassis d. Common Mode or Quadrature Rejection Ratio: 140 decibel minimum at dc; 120 decibel minimum at 60 cps with no unbalance; 100 decibel minimum at 60 cps with 5,000 ohms unbalance e. Common or Quadrature Voltage: ± 500 volts maximum

TABLE 16.3-1. TYPICAL CHARACTERISTICS, TELEMETRY GROUND STATION MAJOR COMPONENTS (Continued)

STRIP CHART RECORDER (Continued)

f. Zero Drift: 0.25 divisions/10° C maximum from 0 to 50° C; 0.1 divisions maximum from 103 to 127 volts
g. Gain Stability: 1 percent maximum from 0 to 50° C and from 103 to 127 volts
h. Noise (maximum peak-to-peak at calibrated gain): 0.25 divisions
i. Maximum non-linearity: 0.25 divisions
j. Internal calibration: 10 millivolts ±2 percent.

MAGNETIC TAPE RECORDER, FR-600

Tape Speeds	60, 30, 15, and 7-1/2 inches/second
Reel and Tape Sizes	10-1/2 or 14 inches NAB standard reels, interchangeable. Easily converted from one-half inch to 1 inch tape width
Flutter	Below 0.3 percent peak-to-peak, cumulative, from dc to 10 kilocycles, 95 percent of time at 60 ips.
Fast Mode Times	Fast mode rewind or fast forward time is less than 3 minutes for 5,000 feet of tape
Tape Speed Error	Not more than ±0.05 percent
Frequency Modulation Record/ Response System	Frequency Response: dc to 20 kilocycles ± 1/2 decibel at 60 ips dc to 10 kilocycles ± 1/4 decibel at 30 ips dc to 5 kilocycles ± 1/4 decibel at 15 ips dc to 2 kilocycles ± 1/4 decibel at 7-1/2 ips
Harmonic Distortion:	Not more than 1.5 percent over band pass
Signal-to-Noise Ratio:	48 decibels at 60 ips and 30 ips 46 decibels at 15 ips 40 decibels at 7-1/2 ips
D-c Drift:	Not more than 1 percent of full output over a 24 hour period
A-c/D-c Linearity:	Not more than ± 1 percent of a zero base straight line

TABLE 16.3-1. TYPICAL CHARACTERISTICS, TELEMETRY GROUND STATION MAJOR COMPONENTS (Continued)

MAGNETIC TAPE RECORDER, FR-600 (Continued)		
	Input Impedance:	20 K ohms, unbalanced to ground
	Input Level:	1 volt rms nominal, adjustable from 0.1 to 25 volts rms to produce full deviation of the carrier
	Output Impedance:	1 K ohm
	Output Level:	1.0 volt rms into not less than 10 K ohm load.

16.3.2 OPEN-LOOP CHECKOUT SYSTEM. The modulated RF signal (FM/FM and PAM/FM/FM) from the vehicleborne telemetry transmitter travels through the GD/C coupling system on the service tower and then radiates through the air to receiving stations at various locations at the test range (see Figure 16.3-2). The receiving stations detect and record the modulation intelligence.

The system is controlled by manual adjustment of the receiving, detecting, and recording equipment.

Major components of the open-loop checkout system are as shown in Table 16.3-2.

TABLE 16.3-2. MAJOR COMPONENTS OF OPEN-LOOP CHECKOUT SYSTEM

COMPONENT	TYPE	GD/C NUMBER	REMARKS
Both Antennas	Corner reflector, Andrew 19140	80-09900-004	Gain: 7.5 to 8.5 decibels over a half-wave dipole
Coaxial Cable	Flexible, 50 ohm, Times MI 1495	0-00036-19	
Coaxial Cable	Flexible, 50 ohm, Military No. RG-225/U		
Complex 36 Blockhouse Telemetry Ground Station (see Figure 16.3-1).			Typical characteristics of the major components of the Telemetry Ground Station are presented in Table 16.3-1.

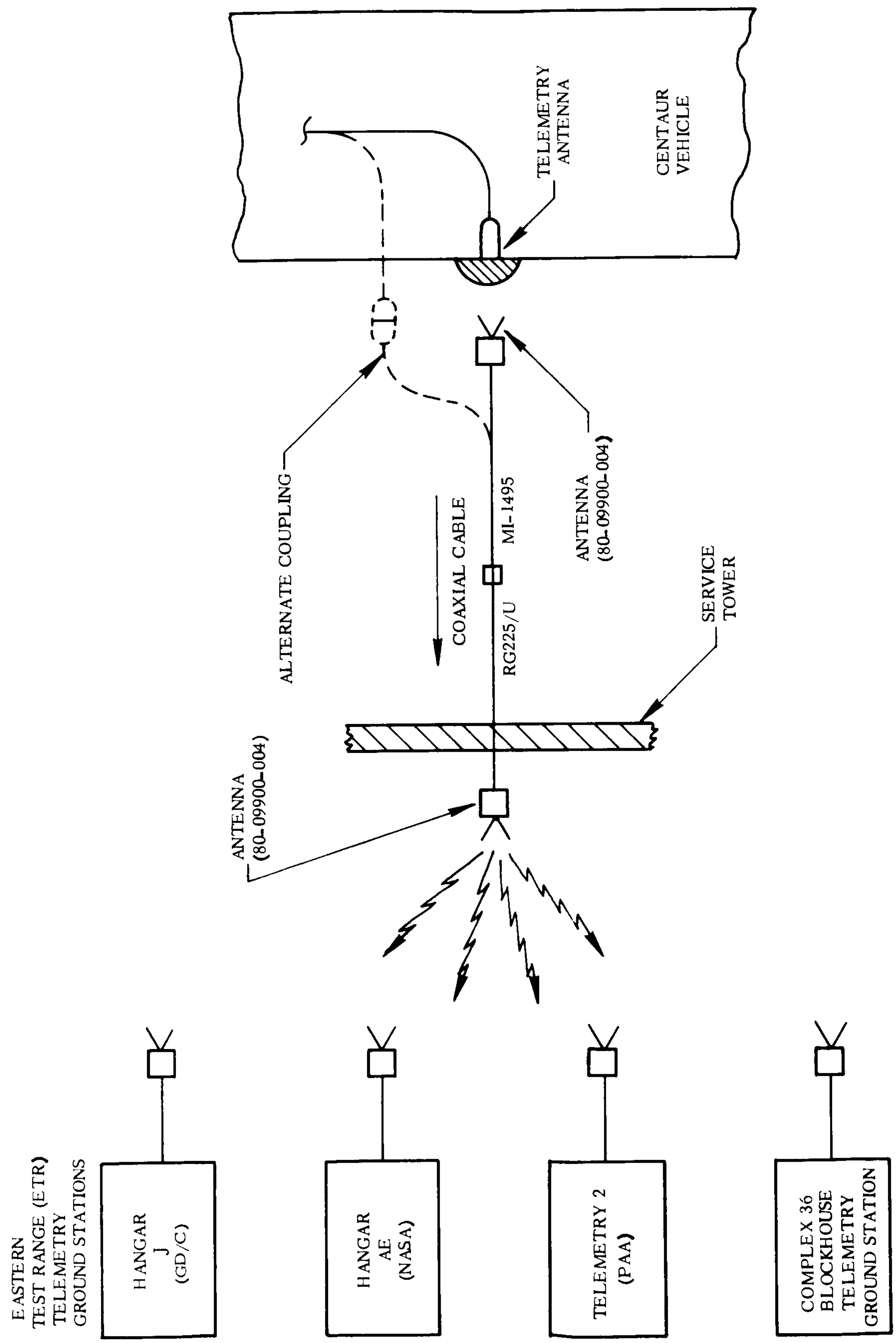


Figure 16.3-2. Centaur Telemetry System Test, Open Loop

16.3.3 CLOSED-LOOP CHECKOUT SYSTEM. The RF output of the vehicleborne telemetry transmitter travels through a coaxial cable coupling system to the telemetry receiving station in the first (basement) floor of the Complex 36 blockhouse (see Figure 16.3-3). Here, the signal is received and the modulation intelligence is detected and recorded.

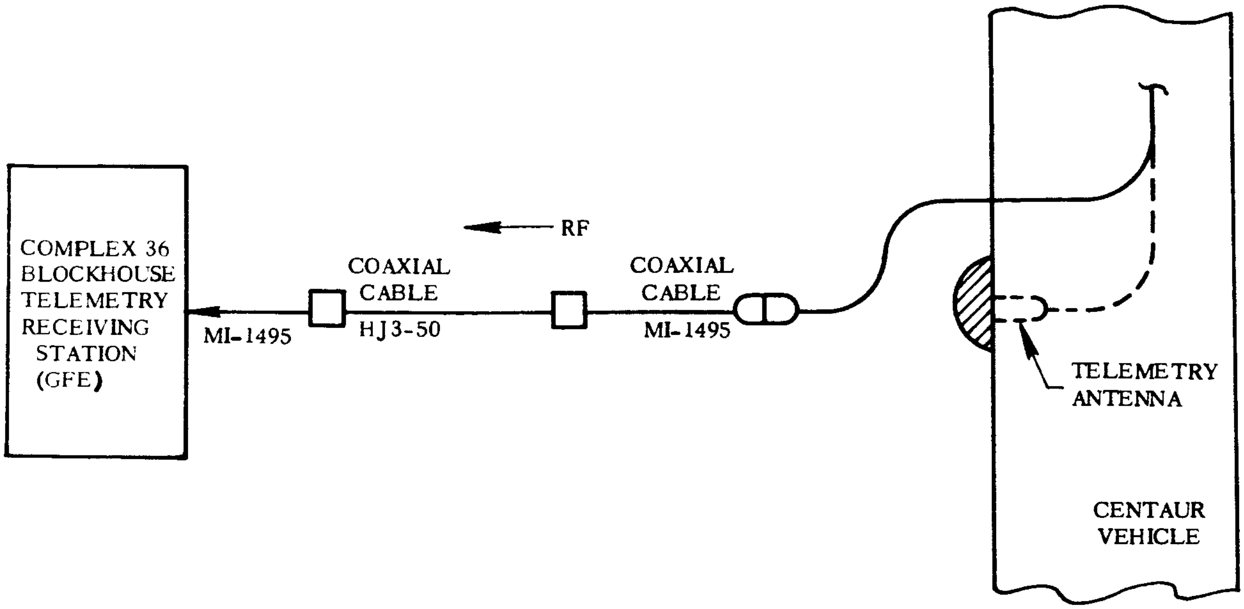


Figure 16.3-3. Centaur Telemetry System Test, Closed Loop

The system is controlled by manual adjustment of the receiving, detecting, and recording equipment.

Major components of the closed-loop checkout system are as listed in Table 16.3-3.

TABLE 16.3-3. MAJOR COMPONENTS OF CLOSED-LOOP CHECKOUT SYSTEM

COMPONENT	TYPE	GD/C NUMBER	REMARKS
Coaxial Cable	Flexible, 50 ohm, <u>Times</u> MI-1495	0-00036-19	
Coaxial Cable	Semiflexible, 50 ohm, 3/8 inch diameter, <u>Andrew</u> HJ3-50	0-00036-18	
Complex 36 Blockhouse Telemetry Ground Station	(Same as in Open-Loop System, Figure 16.3-1)		

16.4 TELEMETRY INSTRUMENTATION

The telemetry instrumentation system is devoted to operational-type measurements and operates in conjunction with the telemetry system during ground operations and flight. Measurements originating on the Centaur vehicle at transducers and signal sources are telemetered by the Telemetry system as specified in instrumentation log sheets issued for each particular vehicle. A listing of telemetry measurements required for a vehicle designed for a two-burn mission is presented in Table 16.4-1 by vehicle system, measurement type, and number of measurements required.

TABLE 16.4-1. CENTAUR VEHICLE TELEMETRY MEASUREMENTS (AC-12 CONFIGURATION)

VEHICLE SYSTEM \ MEASUREMENT TYPE	NUMBER OF MEASUREMENTS										
	SPEED (RPM)	CURRENT	DEFLECTION	PRESSURE	RATE (GYROS)	TEMPERATURE	VOLTAGE	DISCRETE	FREQUENCY	POSITION	TOTAL
AIRFRAME								1			1
RF SYSTEMS						1	2	5			8
ELECTRICAL		1					4		1		6
PNEUMATICS				5		3		2			10
HYDRAULICS				2		2					4
GUIDANCE						1	18				19
AIRFRAME SEPARATION			1								1
PROPULSION	4			12		20		8			44
FLIGHT CONTROL					3		4	34			41
PROPELLANT UTILIZATION							2			2	4
PAYLOAD INTERFACE			3	1		1					5
TOTAL:	4	1	4	20	3	28	30	50	1	2	143

SECTION XVII

LANDLINE INSTRUMENTATION

17.1 INSTRUMENTATION SYSTEM

17.1.1 OPERATION MANUAL. A detailed description of the landline instrumentation system may be found in the Operation and Maintenance Manual, Instrumentation System, ETR Complexes 36A and 36B, GD/C Report No. GDC-BYH64-002. This manual provides information for familiarization with the landline instrumentation system and for calibration and periodic maintenance of the system. The referenced manual contains the following categories of information:

Section I. GENERAL INFORMATION. Consists of an introduction to landline operations at the block-diagram levels with a general explanation of subsystem operation.

Section II. TECHNICAL DISCUSSION. Discusses the technical aspects of major components and equipment.

Section III. CALIBRATION. Contains information pertinent to end-to-end calibration and scale-factor calibration of landline system components.

Section IV. MAINTENANCE. Contains procedures for accomplishing periodic maintenance and for troubleshooting at the systems level.

Section V. DRAWING BREAKDOWN. Lists, in indentured form, the drawings applicable to the landline instrumentation system at Complexes 36A and 36B.

17.1.2 SYSTEM FUNCTION AND CONTROL. The landline instrumentation system provides the capability to gether, condition, and record performance data on vehicle systems and Ground Support Equipment (GSE) systems during prelaunch and launch test operations. Data signals in the form of voltage or current fluctuations originate from transducers and pickup points on the vehicle, GSE, and launch control equipment. These data signals are then conducted through transmission lines and interconnecting cables to system termination cabinets and patch panels for distribution through conditioning and calibrating equipment to the landline recorders.

The landline instrumentation system is used to collect data of the following types:

a. Sequence Indication
b. Temperature measurement
c. Pressure
d. Linear and angular deflection
e. Structural strain
f. Vibration

g. Rotation
h. Liquid level
i. Flow rate
j. Shaft speed
k. Voltage and current.

In general, the landline instrumentation system equipment may be classified into three categories as follows:

a. Measurement acquisition.

b. Signal conditioning.

c. Data recording.

The system has a high degree of programming flexibility. Measurements may be switched and recalibration accomplished in minimal time. Data signals may be fed directly to recorders or they may be amplified, attenuated, calibrated, rectified, and balanced. Scale-factor calibration techniques reduce setup time and facilitate rapid testing. Figure 17.1-1 shows the signal flow of the instrumentation at the 36B Launch Complex at ETR.

17.1.2 INSTRUMENTATION SYSTEM MAJOR COMPONENTS. The bulk of the landline instrumentation system equipment is located in the blockhouse and instrumentation rooms. The Complex 36B instrumentation system major subsystems and components are as follows:

a. Transducers. Used to sense test parameters.

b. Input Programming Rack (IPR). All signals that require preconditioning or calibration are programmed by this equipment.

c. Thermocouple Reference Oven. This oven establishes a stable reference temperature with which to compare the output of the sensing thermocouple.

d. Excitation, Calibration, and Normalization System (ECAN). This system provides signals for transducer excitation where required, normalizes data signals to the 0 to 5 vdc range, and provides five-point calibration signals.

e. Timing System. This system generates timing signals at a central timing station and transmits them on communication lines to timing terminal units located on the first floor of the blockhouse.

f. Potentiometer – Voltage Calibration System (POVO). This system provides calibration and conditioning facilities for up to 72 channels of voltage or potentiometer transducer information.

g. Instrumentation Control Console (ICC). This console is used to control recorder operations in the blockhouse and to control ECAN and POVO calibration in the Launch and Service Building (LSB) instrumentation room. Recorders

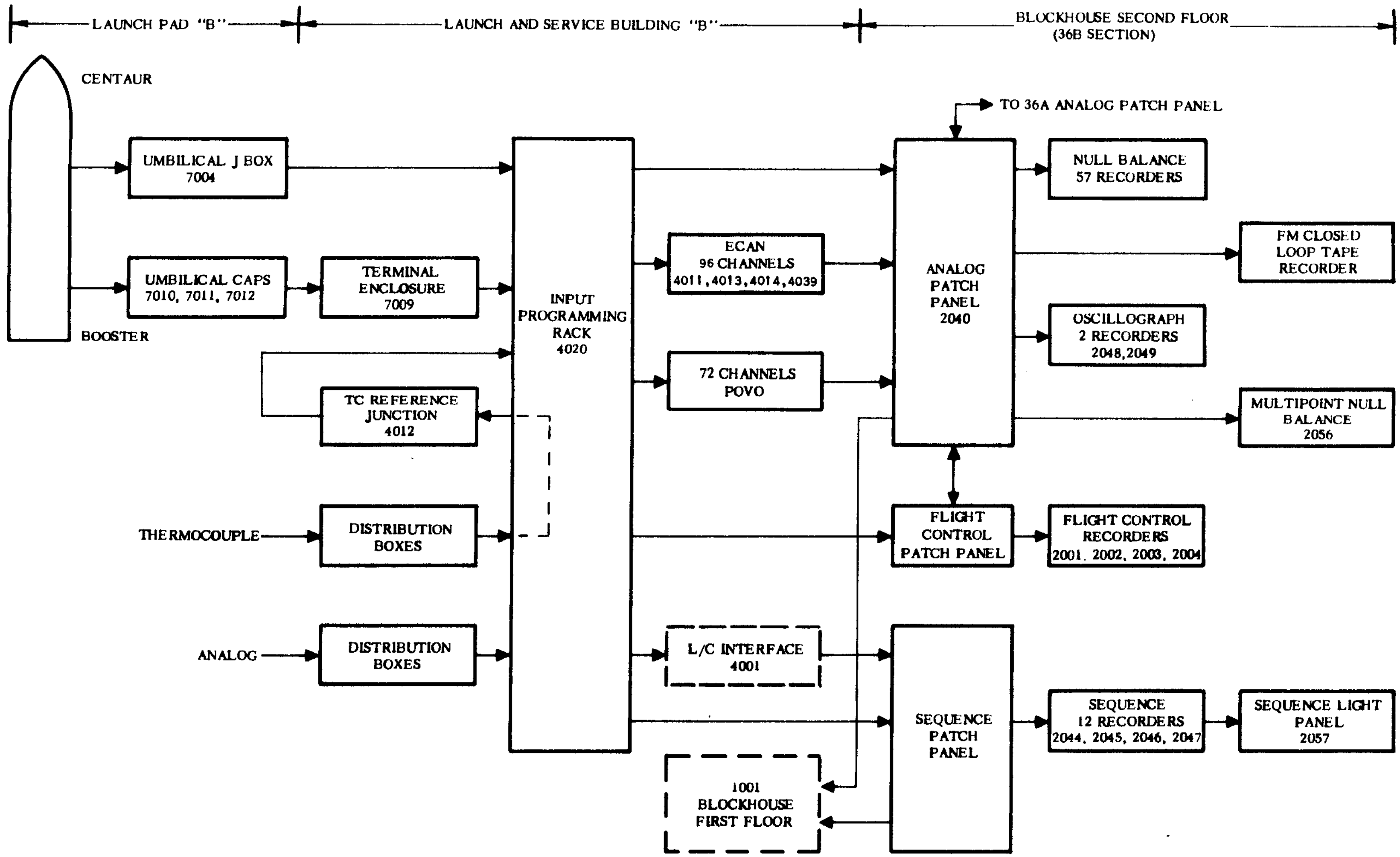


Figure 17.1-1. Landline Instrumentation System Signal Flow Diagram, Launch Complex 36B

that are controlled are the null balance, sequence, and oscillographic recorders.

h. Patch Panels. These panels provide facilities for interconnecting landline system components, for signal monitoring, and for end-to-end troubleshooting.

i. Power Supply System. Alternating current industrial power (480 vac) is received at the launch site power room. Three phase transformers in the power room reduce the incoming supply to 120/208 vac. Application of 28 vdc site power is made directly to the ICC, TV camera supplies, to POVO, and to the camera 13 door interlock.

j. Junction Boxes. Two junction boxes, consisting of Distribution Box 55-17520 and Terminal Enclosure 55-17519, are installed at the launch complex. Each distribution box is approximately six inches square and has one large cable connected to one side, terminating in six smaller cables which enter on another side. The six smaller cables are routed to transducer pickup points. The terminal enclosures are used to terminate the booster stage instrumentation umbilical cables and to provide feed-through connectors for output cables which route to the termination programming bays in the LSB instrumentation vault.

k. Recorders. The following types of recorders are available:

1. Midwestern oscillograph. Used to record up to 24 individual channels of analog data such as stress, pressure, vibration, etc.

2. Brush low-frequency oscillograph. Used to record vehicle autopilot (flight-control) signals.

3. Esterline-Angus Event Recorder. Used for recording sequence events; actuated by 28 vdc on-off signals from launch control and other systems.

4. Esterline-Angus Null-Balance Strip Chart Recorder. Provides a permanent record of slow-response voltage measurements with respect to time.

5. Esterline-Angus Dual-Pen Recorder. Provides two pens using a single chart; pens normally record with different colored ink in each pen. This recorder has adjustable span-and-zero controls, jump-speed and dual-limit switches, and retransmitting slidewires.

6. Esterline-Angus Multiple Station Recorder. This recorder is a 24-point multi-channel cyclic print recorder which alternately records the data from as many as 24 input channels.

7. Honeywell Recorder.

   Four-Pen Recorder. This recorder has four complete and independent measuring and recording systems.

8. Crown Sound Recorder. Contains a 1/4-inch, two-track, magnetic-tape recorder-playback unit. Tape speeds are 3.75, 7.5, and 15 ips.

17.2 LANDLINE INSTRUMENTATION CAPABILITY

The landline instrumentation system measurement capability required to support the Centaur vehicle and associated GSE during ground test operations consists of the type and number of measurements as indicated in Table 17.2-1. Specific details concerning each measurement are in the "Missile Instrumentation Log Sheet" published by GDC for each particular launch vehicle.

TABLE 17.2-1. CENTAUR LANDLINE MEASUREMENTS, AC-12 CONFIGURATION

	Type and Number of Measurements													
System	Acceleration	Rotation Rate	Current	Deflection	Position	Pressure	Frequency	Strain	Temperature	Voltage	Discrete	Flow Rate	Time	Total
Airframe						2			1					3
Separation											2			2
Payload Interface											1			1
Environment Control						7			12					19
Propulsion			1		2	16			19		32			70
Propellant Loading			1		5	7			3	17	33			66
Pneumatic						15					9			24
Hydraulic		2	5			13			2	2		6		30
Electrical Power & Control			18			4				18	47			87
Flight Control			3							16	42			61
Guidance			1								2			3
RF Systems			3							2	6			11
Umbilical Systems				2		11					23			36
Total		2	32	2	7	75			37	55	197	6		413

Instrumentation measurements in support of GSE only are indicated in Table 17.2-2. These measurements are included in the tabular listing published by GD/C.

TABLE 17.2-2. GSE LANDLINE INSTRUMENTATION MEASUREMENTS

GD/C Measurement Number	Description	Range	Units
	ENVIRONMENTAL CONTROL SYSTEM		
CN1910P	Environmental GN_2 Supply Pressure	0 - 3,000	psig
CN1911P	GN_2 Heater Out Pressure	0 - 150	psig
CN1912P	Air-Conditioning Inlet GN_2 Pressure	0 - 150	psig
CN5061P	LN_2 Vaporizer Supply Tank Pressure	0 - 150	psig
CN1271P	Electrical Compartment Coolant Pressure	0 - 30	inw
CN1273P	Thrust Section Duct Coolant Pressure	0 - 30	inw
CN1347P	Payload Compartment Duct Coolant Pressure	0 - 30	inw
CN1547T	Electrical Compartment Inlet Duct Temperature	0 - 100	°F
CN1557T	Thrust Section Supply Duct Temperature	0 - 200	°F
CN1913T	Air-Conditioning Inlet GN_2 Temperature	M20 - 180	°F
CN1560T	Payload Compartment Duct Coolant Temperature	0 - 100	°F
	PROPULSION SYSTEM		
CN1321P	Liquid Helium Dewar Pressure	0 - 100	psia
CN1322P	Liquid Helium Dewar Differential Pressure	0 - 0.5	psid
CN1323T	Helium Dump Valve Discharge Temperature	M430 - 0	°F
	PROPELLANT LOADING SYSTEM		
CN5025P	Liquid Hydrogen Storage Storage Tank Pressure	0 - 65	psia
CN1165T	Liquid Hydrogen Fill/Drain Valve Temperature	M423 - M250	°F
CN5548T	Liquid Oxygen Boom Line Temperature	M310 - M270	°F
CN5069H	Liquid Hydrogen Flow Control Valve Position	0 - 100	percent
CN1533H	Liquid Oxygen Flow Control Valve Position	0 - 100	percent
CN1544H	Liquid Oxygen Topping Valve Position	0 - 100	percent
	PNEUMATIC SYSTEM		
CN5071P	Airborne Helium Purge Bottle Pressure	0 - 3,500	psig
	HYDRAULIC SYSTEM		
CH1062B	C1 Pump Drive Motor Rotation Rate	0 - 15K	rpm
CH1063B	C2 Pump Drive Motor Rotation Rate	0 - 15K	rpm
CH5078C	C1 Pump Drive Motor Electrical Current	0 - 50	ampere
CH5079C	C2 Pump Drive Motor Electrical Current	0 - 50	ampere
CH5076V	C1 Pump Drive Motor Voltage	0 - 208	vac
CH5077V	C2 Pump Drive Motor Voltage	0 - 208	vac

TABLE 17.2-2. GSE LANDLINE INSTRUMENTATION MEASUREMENTS (Continued)

GSE Measurement Number	Description	Range	Units
ELECTRICAL SYSTEM			
CN1466C	28-vdc Normal Power Supply Current	0 - 750	ampere
CN1467C	28-vdc Normal Battery Current	150 - 150	ampere
CN1468C	28-vdc Backup Power Supply Current	0 - 750	ampere
CN1469C	28-vdc Backup Battery Current	150 - 150	ampere
CN5470C	7-vdc Bus Current	0 - 50	ampere
CN1901C	400-cycle Ground Bus Current	0 - 20	ampere
CN5471V	7-vdc Bus Voltage	0 - 10	vdc
CN1900V	400-cycle Ground Bus Voltage	0 - 125	vac
CN1903V	28-vdc Main Bus Voltage	0 - 40	vdc
UMBILICAL SYSTEM			
CN1568D	Lower Boom Rotation	0 - 96	deg
CN1569D	Upper Boom Rotation	0 - 135	deg
CN1452P	Lower Boom ROTAC Supply Pressure	0 - 3,000	psig
CN1453P	Lower Boom ROTAC Return Pressure	0 - 5,000	psig
CN1454P	Upper Boom ROTAC Supply Pressure	0 - 3,000	psig
CN1455P	Upper Boom ROTAC Return Pressure	0 - 5,000	psig
CN1456P	Lower Boom Lanyard Cylinder 1 Pressure	0 - 3,000	psig
CN1457P	Lower Boom Lanyard Cylinder 2 Pressure	0 - 3,000	psig
CN1458P	Upper Boom Lanyard Cylinder Pressure	0 - 3,000	psig
CN1459P	Lower Boom Accumulator Pressure	0 - 3,000	psig
CN1460P	Upper Boom Accumulator Pressure	0 - 3,000	psig